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Creosoting Plant of the Pennsylvania R. R. at Philadelphia, Pa.

By GRANT B. SHIPLEY.*

The second creosoting plant established by the Pennsylvania R. R. is located on tidewater at Greenwich Point, Philadelphia, and is very similar to the railway company's plant at Mount Union, Pa., which was noted briefly in Engineering News of Dec. 17, 1908. The second plant has been in operation for one year and has proved very satisfactory. The buildings and equipment are arranged for two treating cylinders, but as yet machinery has been installed for only half the capacity of the plant. As at present operated the plant can treat annually over 600,000 ties (7 × 9 ins., 8½ ft. long), or the equivalent in board feet of timber. A general view of the plant is shown in Fig. 1, with a train of loaded tie cars ready for the cylinder; at the right is one of the oil storage tanks.

FIG. 1. CREOSOTING PLANT OF THE PENNSYLVANIA R. R. AT GREENWICH POINT, PHILADELPHIA, PA.

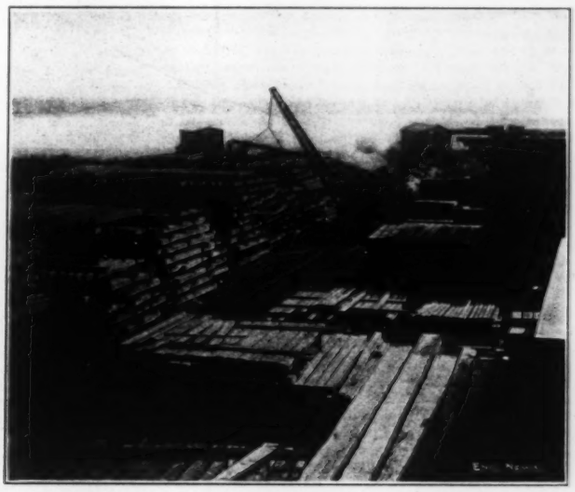

FIG. 2. TIE STORAGE YARD OF CREOSOTING PLANT; PENNSYLVANIA R. R.

The mechanical equipment consists of one cylinder 74 ins. diameter and 133 ft. long, designed for a working pressure of 250 lbs. The shell is of ¾-in. flange steel, with girth seams lap-jointed and double riveted; the longitudinal seams are butt-jointed and triple riveted, with butt straps inside and outside. On one end of the cylinder is riveted a cast steel door frame to which is fitted a built-up door having a cast steel ring welded to a steel plate center dished to a radius of 74 ins. The door is carried on hinge pins with roller bearings in order to reduce the friction and labor in opening and closing. The door frame is turned to suit a wire inserted asbestos gasket which matches the annular spigot on the door ring. The door bolts are of the usual T-head construction, with slots in the door ring so that the bolts can be quickly loosened and swung clear of the door. On top of the cylinder is a dome 36 × 36 ins., this contains an automatic float and valve which closes when the cylinder is full of creosote, thus preventing overflow into the vacuum or air connections. This also indicates to the operator when the cylinder is full. The cylinder is fitted with thermometer, steam and oil pressure gages, vacuum gage and recording pressure and vacuum gage.

The cylinder track is 24 ins. gage, made of heavy angles, and between the angles are fitted the heating coils for maintaining a temperature of 180° to 225° F. The heating coils are protected by a perforated steel plate covering; this is shaped to guide the tram car wheels, thus doing away with angle guard rails. The cylinder is supported on steel saddles that are carried on concrete piers, with one stationary saddle at the center and expansion saddles for the balance.

The air, vacuum and general service pump connections are 8 ins. diameter and those of the pressure pump 3 ins. diameter. The piping is very simple as it can be operated from one floor; it is arranged for both the full-cell creosote and partial-cell Rueping processes. The general service pump is 12 × 8 × 12 ins., of the duplex piston pattern type, with steel rods and cast-iron valves. It is arranged to handle creosote from the tank steamers to any of the three 500,000-gal. storage tanks, or from the latter to the measuring tank in building and from the cylinder to any of the tanks. It can be used for a working pressure of 100 lbs. per sq. in. For maintaining a vacuum on the cylinder there is one single cylinder horizontal vacuum pump 14 × 20 × 24 ins. and jet condenser.

For securing the desired penetration there is a duplex piston-pattern high-pressure pump (7½ × 4 × 6 ins.) for a working pressure of 250 lbs. For operating the Rueping process and displacing the creosote with air there is one duplex air compressor having a capacity of about 400 cu. ft. of free air per min. at 100 lbs. pressure; this discharges into a receiver 4½ × 16 ft.

For fire protection there is a duplex underwriters' pump having a capacity of 500 gals. per min., which is arranged for supplying the fire line and water tower. A 15-KW. generator, direct connected to a vertical enclosed self-oiling engine, furnishes 120-volt current for lighting the building, office and loading platforms. The boiler room contains one 150-HP. internally fired boiler for a working pressure of 130 lbs., a boiler feed pump, and a 300-HP. feed-water heater.

The measuring tank is above the building and holds about 30,000 gals. of creosote; it has a hemispherical bottom and is supported by four columns. The tank is 13 ft. diameter and 30 ft. high; the object of this small diameter and large height is to get an accurate measurement and a static head in order to fill the cylinder rapidly. This tank has two sets of heating coils which maintain a temperature of about 180° to 200° F. There are three 500,000-gal. creosote

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storage tanks adjacent to the main building and near the wharf for receiving the creosote from tank steamers which bring it from Germany or England. The creosote for the Mount Union plant is also received at this plant and then transported in tank cars. All these tanks are fitted with heating coils which will maintain a temperature of 180° F. if necessary; however, it rarely runs over 125° F.

The main building is 144 ft. long and divided into three sections: one for cylinders, 24 × 144 ft.; one for pumps, etc., 14 × 64 ft., and one 32 × 32½ ft. for boilers. This last is partitioned off from the others by a 12-in. fire wall.

The location of Greenwich Point (Philadelphia) is ideal for a treating plant on account of its water and rail shipping facilities. Cargoes of ties and lumber are received from down the coast and the material is transferred to the seasoning yard, which now has in stock over 500,000 ties and 12,000,000 ft. of lumber, etc. Here the material is allowed to season for several months; for treatment, it is piled onto the tram cars of the 24-in. service tracks and a train is run into the cylinder by a 10-ton locomotive; after treatment, the train is drawn out and taken to the loading platform, where the material is loaded onto gondola cars and shipped out for use. The storage yard is served by a locomotive crane, as shown in Fig. 2.

The plant is operated under the management of Mr. E. A. Sterling, Forester of the Pennsylvania R. R., and was built under his direction. The machinery, buildings, tanks, etc., were furnished and installed by the Allis-Chalmers Co., under the supervision of the writer.

A Study of the Ventilation of Sleeping-Cars.*

By THOMAS R. CROWDER,† M. D.

For the purpose of securing a suitable exchange of air in railway cars many types of ventilators have been suggested and not a few have been given practical tests. About three years ago I was asked to report on the efficiency of one of these. It became evident that it would be necessary to establish some basis of comparison, since it does not seem to have been estimated in exact figures to what degree natural ventilation of a railway car is effective. As the problem is of lasting importance and is likely to recur, it seemed advisable to make a fundamental study of the question and to place the results within reach of those who might have occasion to make use of them.

A very simple, if somewhat tedious, means of making this investigation was long ago established by Pettenkofer. It consists of estimating the vitiation of the atmosphere by determining the amount of carbon dioxid it contains, and from this computing the amount of air supplied for ventilation. All air contains carbon dioxid as a normal constituent. The average amount in pure air is commonly stated to be 4 parts in 10,000. This is generally used in ventilation computations, though recent investigation has shown it to be a little too high.

The carbon dioxid in the expired breath averages more than 4% (400 in 10,000). The amount excreted hourly varies according to age, sex and the degree of bodily activity. In a mixed community of persons at rest it will average about 0.6 cu. ft. per person per hour, and the variation will be small.

If there were no ventilation whatever the air of an ordinary railway coach, containing 4,000 cu. ft. of space and occupied by 20 people, would have 34 parts of carbon dioxid per 10,000 of air at the end of one hour. This would continue to increase indefinitely in a direct ratio to the time, since carbon dioxid continues to be produced by the respiration of the occupants at a practically constant rate. But no car is air-tight, and the inside air is being diluted constantly

It is plainly impossible to measure directly the amount of air flowing into a car, since it enters at many points and at constantly changing velocities. But the amount of the interchange may be readily computed from the actual amount of carbon dioxid found from time to time by applying the figures given above to a simple mathematical procedure. Suppose a car contains 20 people and its atmosphere is found to have an average of 10 parts of carbon dioxid per 10,000. The incoming fresh air contains 4 parts, hence the respiratory contamination of the car air is represented by only 6 parts.

The 20 people produce 20 times 0.6 cu. ft., or 12 cu. ft. of carbon dioxid per hour. With what amount of air must the 12 cu. ft. be diluted so that the air will contain 6 parts of carbon dioxid in 10,000? The simple proportion, 6 : 10,000 :: 12 : ?, gives 20,000 as the answer (or 1,000 cu. ft. per hour for each person present). The computation is better represented by the general formula:

$$A = v\,p \div (x - N)$$

v = the CO_2 produced by one person (cu. ft. per hour),
p = the number of persons in the room,
x = the proportion of CO_2 in the air of the room,
N = the proportion of CO_2 in the outside air (0.0004)
A = the air-supply to the room (cu. ft. per hour).

Some 15 or 20 years ago analyses of the air from passenger cars were made by Prof. Nickols, for the Board of Railroad Commissioners of Massachusetts. About the same time the Pennsylvania Ry. took up the subject and had a few tests made. In 1894 a committee of the Master Car Builders' Association made a somewhat extensive report on the subject of car ventilation, and with it submitted the results of several analyses of air from cars (see Table II.).

In 1904, Dudley* reported on analyses of the air of cars of the Pennsylvania Co., which were ventilated by the excellent system which he devised. He found from 10 to 18 parts of carbon dioxid per 10,000 in running cars, and 20 to 21 parts in cars standing still for 20 mins. The 52 people in the cars are assumed to have produced 0.72 cu. ft. of carbon dioxid each per hour; from which is estimated 26,000 to 62,000 cu. ft. of air-supply per hour for the moving and 22,000 to 23,000 for the still cars. More recently the air of cars running in the New York Subway (but more particularly of the subway itself) has been thoroughly studied experimentally by Soper.† Similar studies have been carried out in Paris by Lucien-Groux and others. But these cars have little in common with the railway coach.

In literature on this subject, the information concerning the actual conditions of the air in railway cars is very meager. It is adequate on the application of ventilating devices, but there is no series of analyses extensive enough on which to base any comprehensive opinion as to the deficiencies of natural ventilation to be overcome, or as to the adequacy of the devices applied in keeping the air of the breathing-zone freed from the products of respiration.

The ventilating device upon which this report is based is designed to remove air by exhaustion from the upper portion of the car, and its operation is dependent on train motion.‡ Anemometer readings, have shown that each such exhaust ventilator will remove an average of about 15,000 cu. ft. of air per hour at a train speed of 40 m. p. h., and proportionately more or less for faster or slower speeds. While there is considerable variation under apparently similar conditions, the outward flow is constant. One ventilator is placed over each alternate section of a sleeping-car, while two are applied to the smoking-room and one to the stateroom. Toilet and dressing-rooms are also equipped with one each in recent practice.

It is readily seen that a very large volume of air leaves the car through these openings; it must enter somewhere. The question was, does it enter at such places and take such courses as to cause a free dilution of the air at the breathing level in the occupied car? There seems no adequate way to answer this question except by determining the carbon dioxid in such air, from which the amount of dilution may be computed as already indicated. It was desirable also to make determinations in cars not having the exhaust ventilators, but depending upon natural ventilation.

Nearly 3,000 carbon dioxid determinations were made for all purposes in connection with this work; about 2,000 of these were of the air from over 200 sleeping-cars. A considerable number were made of the air of day coaches, suburban cars, street-cars, stores, restaurants, offices and the open air for comparative purposes, and others for the purpose of establishing certain facts experimentally. [Table I. gives a summary of the author's tables of records of observations in sleeping cars; Table II. shows the comparison of observations made in various places, and includes the figures of the Master Car Builders' Association, mentioned above.—Ed.]

TABLE I.—SUMMARY OF THE RESULTS OF NUMEROUS TESTS TO DETERMINE THE CONDITION OF THE AIR IN SLEEPING-CARS.
(Normal carbon-dioxid in air; 4 parts per 10,000.)

Cars With Natural Ventilation:	Ave. No. of people in car.	Carbon-dioxid per 10,000 parts of air. Ave.	Min.	Max.	Necessary air to maintain ave. carb. diox. cu. ft. per hr.
1. Decks open; doors and windows closed	15	7.19	3.5	13.0	28,300
2. Ditto, but one or both doors open to vestibule	10	5.40	3.5	8.5	40,700
3. All decks, doors and windows closed	13	8.33	5.5	15.0	18,500
4. In lower berth (A)	16	8.32	5.0	18.0	1,389 per berth
5. In aisle opposite lower berth (B)	16	7.32	4.5	10.0	....
6. In upper berth (C)	21	9.17	4.5	18.5	1,611 per berth
7. In aisle opposite upper berth (D) (4 to 7; windows and doors closed).	21	8.37	6.0	13.0	....
Cars with Exhaust Ventilators:					
8. Decks open; doors and windows closed (day)	13	6.01	4.5	10.0	38,430
9. Ditto; for aisle only (night)	13	6.33	4.5	10.0	41,500
10. One or both doors open to vestibule	14	5.50	3.5	9.0	57,900
11. In lower berth (A)	16	6.96	4.5	13.5	2,027 per berth
12. In aisle opposite lower berth (B)	16	6.33	4.5	10.0	....
13. In upper berth (C)	17	6.70	4.5	10.5	2,222 per berth
14. In aisle opposite upper berth (D) (11 to 14; windows and doors closed)	17	5.95	4.5	9.5	....
Berth Tests.					
15. Cars with natural vent; lower berth	..	8.45	...	....	per berth 1,334
16. Upper berth	..	8.85	...	....	1,237
17. Cars with exhaust vent; lower berth	..	6.31	..	....	2,301
18. Upper berth	..	6.70	...	....	2,222
19. Berth with one person	..	7.36	...	....	1,785
20. Berth with two persons	..	9.91	...	....	2,027

Note—Observations (A) and (B) and observations (C) and (D) were made at the same level (lower and upper respectively) but on opposite sides of the berth curtains.

TABLE II.—COMPARATIVE RESULTS OF TESTS OF CARBON-DIOXID IN AIR.

Place.	No. of observations.	CO_2 per 10,000. Ave.	Max.	Min.	Equiv. hourly air supply per person, cu. ft.
Sleeping cars (body)	294	6.20	10.0	...	2,727
Sleeping cars (berths)	690	6.96	13.5	...	2,027
Day coaches (32 pass.)	43	9.38	21.0	...	1,100
Street cars	45	15.10	29.0	...	541
Elevated cars	17	13.90	26.5	...	674
Suburban coaches	47	14.30	38.0	...	583
Stores	23	8.80	10.0	...	1,250
Restaurants	51	16.10	26.0	...	496
Offices	26	13.91	19.0	...	670
Sleeping cars (12 pass.)	..	18.0	22.0	11.3	M. C. B. report
Chair cars (17 pass.)	..	10.7	15.5	7.0	
Sub'n cars (½ full)	..	13.8	21.7	6.4	

Before proceeding to an analysis of the findings it is necessary to know the amount of carbon dioxid in the air surrounding trains in order to have some basis for computing air-supplies to cars. The locomotive emits an enormous total volume of this gas, which, it is easily conceived, might play a considerable part in the amount of carbon dioxid found in the air of the cars. According to Leissner the air surrounding trains contains from 18 to 22.8 parts carbon dioxid per 10,000. My results are at variance with this; 46 determinations averaged 4.04; the highest was 10, the lowest 3.

It is a matter of ready observation that any lateral wind carries all the smoke from a locomotive stack well out of the path of the following train. Presumably this is true of the invisible gases as well as the visible carbon. When the wind is straight ahead or directly with the train, the smoke and steam are, as a rule, carried high enough by their propulsion from the stack and their heated condition to allow the train to pass under with a clear interval, the heavier particles only, such as the small cinders, falling in its path.

Of course, the smoke and condensed steam do not diffuse as do the invisible gases; but with these is mixed a quantity of sulphur dioxid, for which the sense of smell is very delicate. My observation has been, in the examination of tunnel air, that where flue gases have contaminated the air with 15 to 20 parts of carbon dioxid in 10,000, sulphur dioxid is readily detected. It occasionally happens that sufficient gas is carried into a train running in the open to render sulphur dioxid noticeable. It seems that my determinations of carbon dioxid in the air surrounding trains have not dealt with the conditions that could bring this about. Con-

*Abstract of a paper presented at the annual meeting of the American Public Health Association in 1910. It is now issued by the author in pamphlet form, reprinted from the "Archives of Internal Medicine," January, 1911 (American Medical Association, Chicago).

†Superintendent of Sanitation, The Pullman Co., Chicago.

*"The Passenger Car Ventilation System of the Pennsylvania R. R.," C. B. Dudley.

†"The Air and Ventilation of Subways," Soper; 1908.

‡The Garland Ventilator; Eng. News, Dec. 23, 1909.

quently I conclude that this is a relative rarity, and that 10,000 is a proper average to deal with in considering the air outside of moving trains.

It was soon observed that a few open windows in a moving train admit such a volume of the surrounding air as to render the respiratory contamination almost undetectable. Ventilation as a problem in furnishing an adequate amount of fresh air then disappears. This is a fact which may be verified easily by directly measuring the rate of flow of air through an open window. I have measured up to 50,000 cu. ft. per hour entering through a single side window raised only 6 ins. So we may dismiss the car with open windows from further consideration. And with it the whole subject of summer ventilation, so far as the term "ventilation" refers to supplying air and not to keeping the car closed and turn to the car running in cold weather and with windows closed.

Adding to the open deck windows by opening one or both end doors to the vestibule (the outside vestibule doors remaining closed) would be expected to cause a greater air-supply. Such is the case, as shown by the records. [Table I.] Observations were made also where both doors and all the deck sash were closed. Whatever amount of the outside air enters the car under these conditions must find its way in through natural crevices and is driven in and out by the pressure of the wind and the suction effects produced by the motion of the train. As would be expected under these conditions, the average carbon dioxid is greater than in either of the preceding groups and the computed air-supply is smaller.

The air-supply to sleeping-cars, as computed from 355 carbon dioxid determinations, is (for all but that of the completely closed car depending upon natural ventilation) a large one relative to the number of passengers, and would not allow the average carbon dioxid to go above 10 in any but this one condition unless the cars were crowded beyond their natural capacity. Such overcrowding in sleeping-cars is prevented by the assignment of space and refusing further applicants when this is all taken. It very rarely happens that sleeping-cars carry more than 25 passengers.

It should be understood that all of the above observations apply to the main compartment of the standard sleeping-car in motion; and in setting down the number of passengers only those persons were counted who were actually in this compartment, and who had been there for a period of at least ten minutes at the time the samples of air were being collected. The smoking-room, the drawing-room, and other small rooms constitute separate problems.

In order to test the consistency of the results obtained, and to find if the carbon dioxid actually does go up in proportion to the number of passengers, the 555 observations were divided into four groups, according to the number of passengers (Table III.). It is seen that it increases with the number of passengers:

TABLE III.—RELATION OF AIR POLLUTION TO NUMBER OF PASSENGERS.

No. of Pass.	Carb. diox.; parts per 10,000— Cars with nat. vent.	Cars with exhaust vent.
Under 10	5.91	5.58
10 to 15	6.62	5.95
15 to 20	7.38	6.46
Over 20	8.85	7.24
Average	6.88	6.11

A further method of determining the ventilation of the cars equipped with exhaust ventilators was applied as follows: When trains pass through tunnels the cars receive a considerable amount of engine gas. We may compute the fresh air supplied to these cars by observing the rate of disappearance of this gas (carbon dioxid) after leaving the tunnel. Determinations showed considerable irregularity, but the basic conditions also varied, and the final level to which the carbon dioxid was approaching was different for different cars. It is nevertheless clear that the disappearance of the gas is rapid.

When taking samples of air from the berths it was the rule to take, as near simultaneously as possible, an average sample from the aisle for comparison. Samples from each place were generally repeated at 15-min. intervals, until 20 or more had been collected in the car. Two lower berths on each side of the car were generally selected, and one or two uppers when possible.

Popular opinion ascribes better ventilation to the upper than to the lower berth in a sleeping-car. The reason generally given in support of this opinion is that the berth curtain entirely covers the lower and only partly the upper. It is supposed that the curtain hinders the progress of air-currents. The tests show that the air contamination is not very different on the two sides of the curtain; but it may be contended that this is a matter of equalization by the diffusion of gases, and that the circulation of fresh air is chiefly through the body of the car.

In order to gain some information concerning the conditions that would obtain if the closed berth had to lose its carbon dioxid by diffusion through the curtain, a series of experiments was conducted with the purpose of determining the rate of diffusion under similar conditions. The results show that the berth does not act as a closed compartment, but is essentially a part of the general space of the car body, and is subject to the effects of air-supply and air-currents through and around the curtain very much as it would be were the curtain entirely absent.

Observations were made in crowded smoking-rooms of cars without ventilators. The occupants were from 4 to 7; the carbon dioxid from 10.5 to 20.5 per 10,000. The average carbon dioxid (14.88) with the average occupants (5.85) would be maintained by an air-supply of 3,225 cu. ft. per hour for the room. Similar observations in smoking-rooms equipped with exhaust ventilators showed carbon dioxid from 7 to 16.5 per 10,000, with 4 to 8 occupants. The averages were 6.1 occupants and 11.41 carbon dioxid the equivalent air-supply would be 4,940 cu. ft. No account is taken of the carbon dioxid produced by the burning of tobacco and matches.

About 200 samples of air from still cars have been analyzed. It is usual to find that the carbon dioxid rapidly increases when a train stops running. This increase reaches its maximum only after a considerable time, and the final height is variable, depending largely on the force of the outside wind. A strong wind will drive much air into the car, a light one proportionately less. Among these 200 observations the carbon dioxid passed 20 per 10,000 but twice (20.5 and 21.5), both in lower berths. It is usual to find the maximum around 15 in cars that are occupied at stations awaiting very late departures.

It has been shown that an average of over 40,000 cu. ft. of air per hour enters the breathing-zone of sleeping-cars equipped with the type of exhaust ventilator herein considered. It has been further shown that approximately twice this much air leaves from the upper portion of the car through the six or eight ventilators. In the absence of specific intakes it is difficult to determine exactly in what manner this air finds an entrance.

Sleeping-cars are snugly built; the crevices are small, but no crevice is too small to admit air, provided a little pressure is behind it. A row of windows covers each side of the car, another row of small ones extends along each side at the deck level, and each end has a door. There is a sum total of approximately 500 lin. ft. of crevices at their edges. If they average 1-50-in. in width and admit air at half the rate of the train speed, the 40,000 cu. ft. would be more than accounted for. Some of these crevices are much larger than assumed, some are probably smaller. It is not unusual to find air entering certain areas of open windows at a rate equal to half the train speed, or even more. The crevices may act in the same way; the passage of air through such invisible openings is a much more important means of ventilation than might be thought. Pettenkofer showed that when all visible chinks were closed in a room the rate of ventilation was decreased only 28% as compared with the rate when the doors were closed in the ordinary way.

Samples of air were taken simultaneously from various locations in sleeping-cars with exhaust ventilators and the carbon dioxid determined, in an attempt to find where the contamination is greatest. So long as the samples are taken well within the body of the car they show nearly uniform results for different levels and different locations; hence the general mixing of the air must be good. The carbon dioxid, on the average, is a little less close to the floor than higher up. This is consistent with the upward trend of the flow to the ventilator exits. There is essentially no difference between the breathing zone and the bell-cord level. There is a slight difference between samples taken at the breathing level and near the ventilator exits, the latter being lower; but the difference is not so great as would be indicated by the difference in the dilution of the lower air and the amount leaving the car through these exits.

It has been attempted to determine the ventilation of sleeping-cars in terms of air-supply, using carbon dioxid as the only available basis of computation. In order to pass judgment on the findings recorded, it is necessary to know the hygienic significance of respiratory contamination of the atmosphere, and, if possible, to establish the cause of discomfort which may arise, supposedly as the result of an insufficient air-supply.

According to the older theories the sensations of discomfort arising in enclosed spaces had their origin either in an excess of carbon dioxid or an insufficiency of oxygen. Pettenkofer cast the first serious doubt on the correctness of these theories. Hermans proved that air containing 15% oxygen may contain 2 to 4% carbon dioxid and not be harmful. On removing the carbon dioxid there was no great discomfort even when the oxygen was reduced to 10%.

It seems to be established beyond reasonable doubt that discomfort is not due to any change in the chemical composition of the air, but to physical changes only; and that to maintain a normal heat interchange between the body and the air is to avoid the development of those symptoms which are commonly attributed to poor ventilation. A certain amount of fresh air must be supplied, of course, but the most vital element of the ventilation problem becomes that of regulating the temperature of the air. The question of how to ventilate a railway car is therefore chiefly a question of how to regulate its heat.

It has happened that a few of the cars considered in this work have been uncomfortable, have been called "close" or "stuffy." The temperature of these cars has invariably been high. There has sometimes been an unpleasant odor. This cannot be ventilated away so long as its source remains. A high temperature renders such odors more noticeable. The most marked offensiveness I have ever noticed was in a day coach where the air was of such a degree of chemical purity as to indicate ideal ventilation by any standard that has ever been proposed. The car was hot and had many filthy people in it. On the other hand, with perfect comfort has been sometimes associated the highest chemical impurity.

It seems probable, furthermore, that one main cause of the complaint of poor ventilation in the sleeping-car berth is purely psychic. We are used to sleeping-rooms with walls and ceilings far from us. In the berth they are very close. Their very nearness is oppressive. It seems as if there cannot be enough air in this small space to supply our wants. The sensation is often quite independent of the amount of air supplied and even of the temperature.

Even under the older applied principles of ventilation, the air-supply of sleeping-cars, as determined in this study, is ample under nearly all conditions. The average carbon dioxid in the air of running cars falls well within the limits of contamination permitted by the earlier investigators, and it is relatively rare that the individual observations show more than 10 parts in 10,000. In the light of the newer conceptions, which have as yet been applied in practice only to a very limited extent, this air-supply is ample under all conditions observed. No danger to health is to be apprehended under the conditions ordinarily obtaining even in still cars. They are occupied only for short periods as a rule and are not uncomfortable if kept cool.

It would seem that the results obtained by the type of exhaust ventilator investigated in this study, which is now a part of the standard equipment of Pullman cars, are entirely adequate to meet the demands of hygiene, and that those difficulties and discomforts which do sometimes arise are due to other causes than lack of a sufficient amount of fresh air or to excesive vitiation. It is extremely unlikely that increasing the air-supply, which now amounts to from six to ten or more times the cubic content of the car each hour, and must maintain considerable motion of the atmosphere, would aid in any other way than by making overheating more difficult to bring about.

Overheating is the paramount evil. It is the thing to be chiefly guarded against in the attempt to maintain comfort and good hygiene. It is not feasible to cool the naturally overheated air in summer, or to dry it when excessively humid. Fan motors and open windows are the available means by which the difficulties arising in hot weather may be most readily overcome. Carry away the body heat as rapidly as possible by a strong current of air.

Though the avoidance of overheating in winter would seem to be an easy thing, its accurate control to meet the rapidly changing conditions under which cars may be operated is a matter of great difficulty. Experience has shown that it is necessary to have in sleeping-cars at least twice as much radiating surface as is demanded in common practice for heating the same space in houses; this in order to warm the large volume of air received and discharged so that it will maintain comfort to inactive passengers. To decrease this surface would be to fail to maintain a sufficiently high temperature on occasion.

A system is needed capable of being quickly and effectively controlled to meet rapidly changing conditions. Such a system is now being experimented with in which there are multiple units of radiating surface, each with a separate control. The results so far indicate that from this a more uniformly comfortable condition can be maintained.

THE STEEL PRODUCTION OF THE WORLD in 1910, according to the "Engineering and Mining Journal," was approximately 58,000,000 metric tons, showing an increase of 8.4% over 1909. The United States, Germany and Great Britain together produce about 80% of the world's total. Their production in metric tons is classified as follows:

	United States.	Germany.	Great Britain.
Converter:			
Acid	9,563,376	171,108	1,156,313
Basic	....	8,030,571	651,268
Open-hearth:			
Acid	1,231,575	252,148	2,695,482
Basic	15,537,006	5,125,421	1,603,793
Crucible	124,280	83,202	....
Electric, etc.	56,220	36,188	....
Total	26,512,437	13,698,638	6,106,856
Prop. steel to pig iron	95.6%	92.6%	58.8%

Electric Power for Irrigation; U. S. Reclamation Service.*

By O. H. ENSIGN,† M. Am. Inst. E. E., and JAMES M. GAYLORD,‡ Assoc. Am. Inst. E. E.

The subject of electric power transmission applied to irrigation covers a very broad field of electrical, hydraulic and mechanical engineering. It presents problems of finance and agriculture and must also be viewed from the humanitarian standpoint. There are a number of distinct conditions which lead to the use of transmitted power for pumping in connection with irrigation projects. The more important of these conditions are the following:

(1) In some cases high lands which cannot be reached by the diversion works constructed for a gravity system can be reached by pumping water from the gravity canals into canals feeding such high-land areas.

(2) The irrigated area may be advantageously extended by pumping from wells, thus drawing on the underground sources and tending to keep the water plane down, this plan being particularly desirable in certain cases, as will be explained farther on in this article.

(3) Pumping may also be applied to the drainage of low land, water being pumped to either irrigation or waste ditches.

In connection with the diversion works, it frequently occurs that a considerable amount of hydraulic power can be advantageously developed, and in such cases this power may be transmitted and applied to any or all the purposes named above. Where hydraulic power cannot be developed, steam or other engines must of course be employed.

This paper will be devoted mainly to the discussion of two hydroelectric transmission systems constructed by the Reclamation Service, one applied to the irrigation of high lands by pumping from gravity canals, and the other applied to the extension of the irrigated area by pumping from the underground sources. The former of these has been nearly completed. In the latter, however, only a small portion of the contemplated development has been finished.

It may not be inappropriate in this discussion to call attention to the advantages of pumping the ground waters of an irrigated area. The advantages of such a plan are, first, to prevent the rise of the ground waters to a point dangerously near the surface and, second, to supplement by means of drawing on the underground supplies the water stored in the reservoir or diverted from the natural flow of the streams.

The rise of the ground waters damages the land in an arid climate by allowing evaporation to take place from the surface or from near the surface of the ground, thus increasing the amount of deleterious salts in the surface soil, gradually causing the land to become alkaline in character and non-productive, hence it is essential that the water plane should not rise beyond a certain limit.

It may generally be considered that the thorough watering for irrigation purposes of a large area of land which heretofore has been drained by the rivers which have flowed through it will tend more or less to cause a rise of the ground waters, hence the importance of this particular phase of irrigation.

In some cases the natural underground drainage may be such that the rise of the water plane will be limited to a reasonable depth below the surface, but there are many examples in the West where this has not been the case and lands which were once unusually productive have been made valueless on account of the rise of the water plane. In some instances it may be necessary to drain this water off and let it waste, because it may carry a percentage of salts that would damage the land, but in the majority of cases it may be pumped from wells into canals and distributed.

Southern California presents a good example of this condition, for practically two-thirds of the water supply for this wonderfully productive area is obtained from underground sources. The water plane in a large section of this area is maintained at least 50 ft. below the surface of the ground, thus giving good drainage and constantly improving the condition of the surface soil. All of this pumped water is used for irrigation.

In all irrigation projects, whether by gravity or pumping, the first thing to be borne in mind is, will it pay? That is, can the land stand the charge for the development and the cost of operation of the same? Here the question of climate and the class of products which can be raised upon the soil must be taken into consideration. In some localities a cost of $40 per acre would be a limiting price for the development. In other cases a charge of $100 per acre would not be excessive. The charge for maintenance and operation may vary from $2 to $25 or $30 per acre per annum, the nature of the crop being the controlling feature. It might be mentioned that alfalfa is being grown in Southern California, irrigated by water which is pumped from wells, and that orange groves are irrigated by water pumped in some cases as high as 200 ft., both with apparent financial success. On the other hand, for irrigation in the northern climes, where the season is short, and such crops as alfalfa, grain, potatoes, etc., must be depended upon, the maintenance cost per acre must be kept at a minimum.

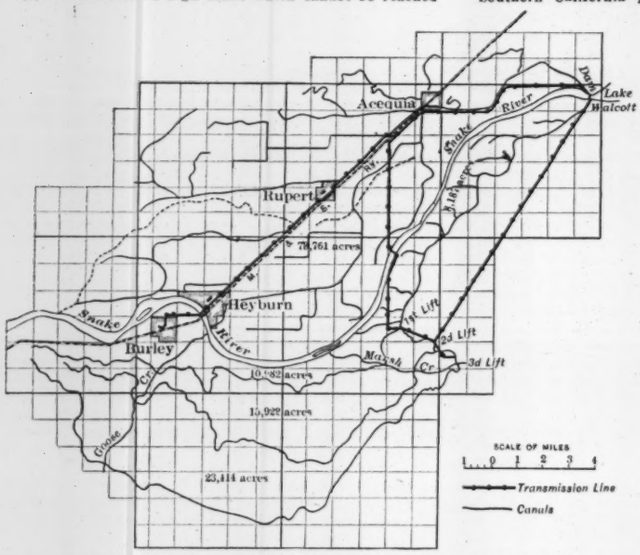

FIG. 1. MAP OF THE MINIDOKA RECLAMATION PROJECT.

Minidoka Project.

POWER GENERATION.—In the central southern part of Idaho, along the Snake River, the U. S. Reclamation Service has constructed what is known as the Minidoka project. This comprises 130,000 acres, of which, roughly, 70,000 are fed by gravity system on the north side of the river, 10,000 by gravity on the south side of the river, and the remaining 50,000 acres on the south side are supplied with water pumped from the south side gravity canal. (See Fig. 1.)

The Minidoka dam, designed primarily to divert water into the gravity canals, was constructed during the years 1904 to 1906. It is a rock-filled dam with concrete core, located near the foot of the rapids in the Snake River. It creates a fall which averages 43 ft. through the various stages of river discharge, and thus offers an excellent opportunity for development of power.

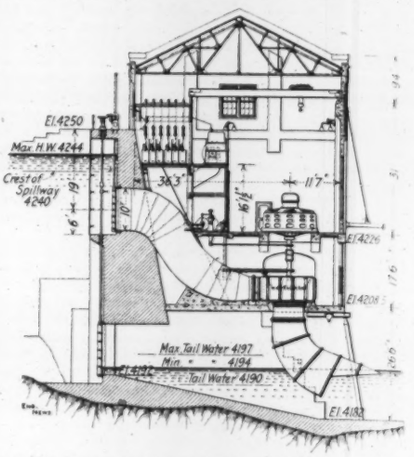

Fig. 3. Cross-Section of Power Station, Minidoka Project.

A deep sluicing channel was made through the lava formation on the north side of the river, and in this sluicing channel was constructed the concrete dam shown in Fig. 2. This structure was built, so far as could then be foreseen, without complete power plant designs, so that it could later be used for the development of power. Through the base of this dam are five sluicing gates, and higher up are ten 10-ft. circular openings to be used for the power development.

In February, 1908, instructions were given to proceed with the design and construction of a plant at this point to supply power for pumping water to the high-land area 15 miles distant. This work was immediately under

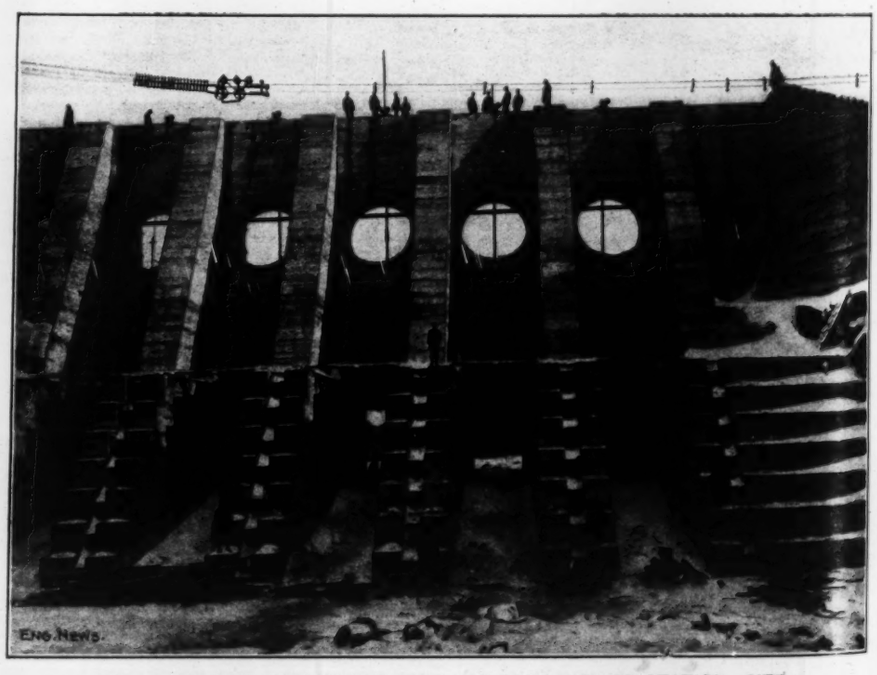

FIG. 2. INTERIOR OF DAM AT LAKE WOLCOTT; POWER STATION SITE.*

*From a paper presented at the Pacific Coast Meeting of the American Institute of Electrical Engineers, Los Angeles, April 25-28, 1911. Copyright 1911, by the American Institute of Electrical Engineers.

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taken and pushed with all possible speed. On the 8th day of May, 1909, one unit in the power plant and one unit in each of the three pumping stations were started and operated throughout the irrigation season.

The power-plant equipment includes five 1,400-KVA., three-phase, 60-cycle vertical alternators, each connected to a 2,000-HP. turbine; two 120-KW., vertical exciter units, each direct connected to a 180-HP. turbine; the governors being returned to an open tank in order to allow the oil to settle and any entrained gases to escape. Governor heads are provided with means of control from the switchboard, this control being sufficiently close for synchronizing and dividing the load between units, and if need be the turbines can be started and stopped by the switchboard operator.

The turbines were designed for an effective head of 46 ft., maximum load of 2,000 HP., speed of 200 r. p. m. The maximum efficiency guaranteed is 81.5%. The guaranteed average efficiency between half and full gate is 77%.

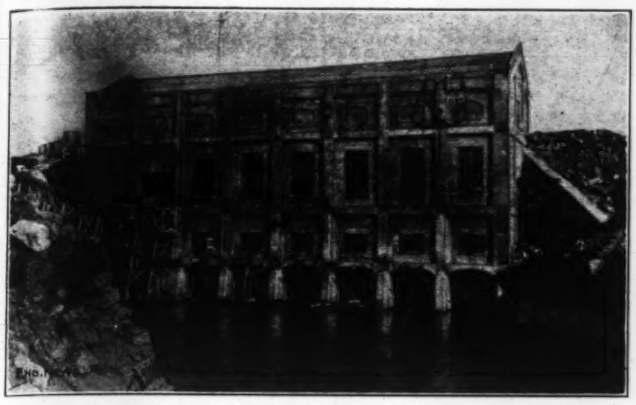


FIG. 4. MINIDOKA POWER STATION, LAKE WOLCOTT, IDAHO.

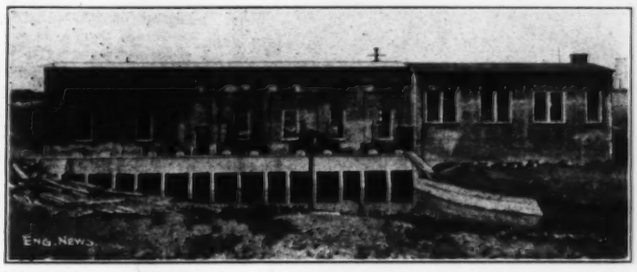


FIG. 6. PUMPING STATION NO. 1.

and five three-phase, air-blast transformers, delivering 33,000-volt current.

The turbines are on the lowest floor of the power plant and are carried upon heavy reinforced-concrete arches, built up from the bottom of the diversion channel and the buttresses of the dam. The alternators rest upon a reinforced concrete structure and are connected to the turbine shafts by means of clamp couplings. The thrust bearings are located on top of the alternators, which puts the shafts in tension. These are plain collar bearings running in simple oil baths, without pressure, and this type of bearing has proven entirely satisfactory. They have given no trouble whatever in two years' operation. The arrangement of the exciter units is identical with that of the main generators, except that in the case of the exciters the thrust bearing is located on top of the turbine.

In order to utilize the waste room resulting from the peculiar construction of the dam and the space occupied by the penstocks, a gallery was constructed the entire length of the building along the lower face of the dam and on this gallery are placed the air-blast transformers and high-tension oil switches. The 33,000-volt bus-bars are carried on insulators above this gallery from the south to the north end of the building, where they enter concrete cells and are led to the line switches located at this end of the building on the generator floor. Below the transformers is a large air duct supplied by two motor-driven fans, and below the air duct on the generator floor all of the governor apparatus is placed. The operating switchboard is at one end of the station and the portion now installed, including the total output panel, faces the machines it controls. It is intended later to extend the present building by adding a wing along the north side of the tailrace, and that portion of the switchboard shown on the drawing for future installation will face this extension. The lightning arresters are located on a special gallery above the switchboard proper.

The governors for the main turbines are all supplied from a central oil-pressure system, consisting of two gear pumps, driven by 40-HP. direct-current motors, suitable pressure tanks and brass-pipe distributing lines. No receivers or vacuum tanks are used, the oil from

The electrical apparatus is connected, on the unit system, to duplicate 33,000-volt bus bars. All synchronizing is done at 33,000 volts, oil switches being provided on the high-tension side of the transformers only. These switches are located adjacent to the transformers and are remote controlled. Provision has been made for two transmission lines, either of which can be operated from either bus.

The operating characteristics of the machine are: Alternator, regulation at 100% power factor, 8%; efficiency at full load, 96%; temperature rise at full load, 40°; transformer, regulation at 100% power factor, 0.9%; temperature rise at full load, 40°; efficiency at full load, 98.4%.

TRANSMISSION.—The transmission line, consisting of a single circuit of No. 3 and No. 5 B. & S. copper, carried on wooden poles, is 22 miles in length and crosses the Snake River in an 1,150-ft. span of six-strand, 83,000-cir. mill copper cable at a point 11 miles below the power plant. A second similar line is being constructed on the south side of the river, using No. 5 wire, and the two lines will be connected as a loop system through the stations and to the towns on the project which are being supplied with light and power.

PUMPING.—There are three pumping stations, each having a lift of 31 ft. No. 1 contains 5 pumps, four of 125-sec.-ft. capacity and one of 75-sec.-ft. capacity; No. 2 has four pumps, each of 125-sec.-ft. capacity; and No. 3 has three pumps, two of 125-sec.-ft. and one of 75-sec.-ft. capacity. The general arrangement of these pumping stations is shown in Fig. 5.

The problem in a system of this kind is to supply at as high an efficiency as practicable, taking into consideration operating conditions, first cost and maintenance, water in variable quantities with the least liability of shut-down and the least possible operating expense. Bearing this in mind, the choice of design of pumping station and especially the arrangement of the pumping units requires no small amount of study. The ordinary horizontal pump with the necessary foot valves would have made an expensive and awkward plant, and such an arrangement would have required a much larger amount of floor space than that occupied by the vertical units which were finally decided upon. The foot valves alone would have introduced a serious loss of head by offering considerable friction, and the control of the discharge of the water by means of gate valves would have involved an expensive installation and a constant source of annoyance in operation. The idea of controlling this pump by means of a cylinder gate, similar to those used in water turbines, resulting from a careful study of the problem, was carried out with very satisfactory results. By means of this gate the flow of water in the canals is under close control by the operator in the pumping station.

The pumps are installed in separate compartments and are direct connected to synchronous motors located directly above them and supported by a heavily reinforced concrete structure. As in the case of the generators at the power-house, the weight of the rotating element is carried by thrust bearings located on top of the motors. In this case, however, the bearing is of the roller type, this style of bearing having been adopted on account of the necessity of reducing friction to a minimum in starting the synchronous motors.

Motor-operated, steel-plate, sliding gates are used to admit water from the forebay to the pump pits, two gates being provided for each pit. Provision has been made for pumping out the pits in order that the synchronous motors may be started without load other than friction and windage of the rotating parts. For this purpose an auxiliary 6-in. centrifugal pump was provided and arranged so that its suction could be connected to any pit and the water entirely removed before the motor is started.

When the plant was first designed, it was thought inadvisable to adopt an arrangement by which the pumping units could be started in quick succession, on account of the danger of the sudden rush of water down the canal injuring the banks. The auxiliary pump, therefore, is of only sufficient capacity to permit starting of pumps at intervals of 20 to 30 minutes. Two years' operation has shown this to be an unnecessary precaution, and by means of a specially designed starting valve each pump is now arranged so that it can empty its own pit while the motor is running on the compensator in starting. As soon as the pit is emptied the motor approaches synchronous speed and the field is excited. This arrangement has worked out very satisfactorily, and by its use a pump can be started up and put into full operation inside of two minutes.

Each pump has but one guide bearing, a long sleeve with a stuffing box at the top, and near the top of the sleeve the bearing is supplied with a semi-hard oil having the consistency of vaseline, forced in by a special motor-driven pump for each individual bearing. Lubricating in this manner forces the lubricant downward and excludes water from the bearing and any possible grit which may be in the water. In two years' time no rust or wear is shown on these bearings, the shaft being as bright as when it came from the factory.

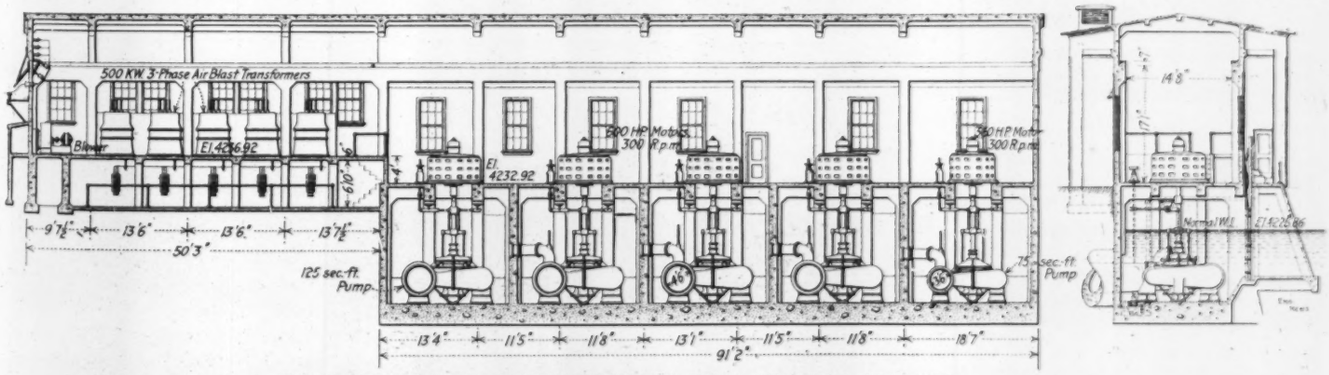


FIG. 5. SECTIONS OF PUMPING STATION, NO. 1; MINIDOKA PROJECT.

Curves giving the characteristics of the pump as to efficiency, power and gate openings are shown in Fig. 13.

The upper end of the 5½-ft., concrete, force mains leading from the pumps is closed by a check valve, to prevent water from running back to the pump in case of a shut-down. This valve is made up of ¼-in. boiler

Fig. 7. Interior of Pumping Station No. 1.

plate slightly bumped, hinged from the top of the head wall and seating against rubber packing set in a cast-iron ring.

The motors for driving the 125-sec.-ft. pumps are of the self-starting synchronous type, operating at 300 r. p. m. and receiving current at 2,200 volts. The efficiency at full load, 100% power factor, is 94%; the regulation at 100% power factor is 8%; the temperature rise at full load is 40°. The motors for operating the smaller pumps are similar except that they have a capacity of 360 HP.

The rotors are provided with squirrel-cage windings, to permit starting as induction motors, receiving for this purpose current at low voltage from compensators.

The step-down transformers are of the three-phase, air-blast type, receiving 30,000-volt current through oil circuit breakers from the high-tension bus and delivering the 2,200-volt current through disconnecting switches and expulsion fuses to the low-tension bus.

In pumping station No. 2 are installed the transformers necessary for station No. 3. The distance between stations 1 and 2 is 1½ miles, and between stations 2 and 3 three-quarters of a mile, the highest voltage carried to the latter station being 2,200 volts.

The exciters and blowers for the transformers are driven by induction motors and a motor-driven air compressor has been provided for cleansing the apparatus in each station. Lightning protection is provided in the form of electrolytic arresters placed inside the building.

All the switching apparatus in the pumping stations is operated by distant mechanical control. A single high-tension bus has been provided, but provision has been made by means of disconnecting switches for receiving power from either or both transmission lines.

Table I. shows construction costs and when considered in connection with the strenuous conditions under which these plants were constructed, is of interest. The figures given in the table do not include the cost of operators' quarters and road making. These items have been omitted, since they are so greatly dependent upon local conditions. The erection costs, however, include several items such as the cost of making preliminary tests of the hydraulic apparatus, the cost of temporary buildings for housing machinery during the time the permanent buildings were under construction and other items made necessary by the severe conditions under which the plants were constructed.

In Table II. is shown the estimated operating cost, based on the actual cost of operation during the season of 1910, of that portion of the equipment then installed. There are two operators on each shift at the power-house and there will be but one operator on each shift at each of the pumping stations. The cost of repairs during the season of 1910 was so ridiculously low that the figures given in the table are greatly in excess of the actual cost of repairs last year. This also applies to superintendence and general expense. Five per cent. per annum depreciation has been allowed on the power installations, including buildings, and 10%

TABLE I.—CONSTRUCTION COST OF MINIDOKA POWER AND PUMPING SYSTEM.

	Power plant.	Pumping station No. 1.	Pumping station No. 2.	Pumping station No. 3.	Transmission line.	Total.
Capacity	6,500 KW.	2,500 KW.	3,000 KW.	1,300 KW.	6,500 KW.	6,500 K
Building	$80,200	$34,500	$40,300	$19,200	....	$174.
Machinery	167,600	78,800	73,600	32,500	....	352.
Freight and hauling	25,100	11,800	10,600	6,100	....	53.
Erection	62,300	18,200	16,800	8,600	....	105.
Engineering and incidentals	13,600	5,600	5,300	2,800	....	27.
Tail race	56,000	....	....	....	....	56.
Pressure pipes	....	19,000	14,000	16,600	....	49.
Double transmission line	....	....	....	....	35,000	35.
Total	$405,400	$167,900	$160,600	$85,800	$35,000	$854.
Unit cost	$63.00	$67.00	$53.00	$66.00	$5.40	$13.

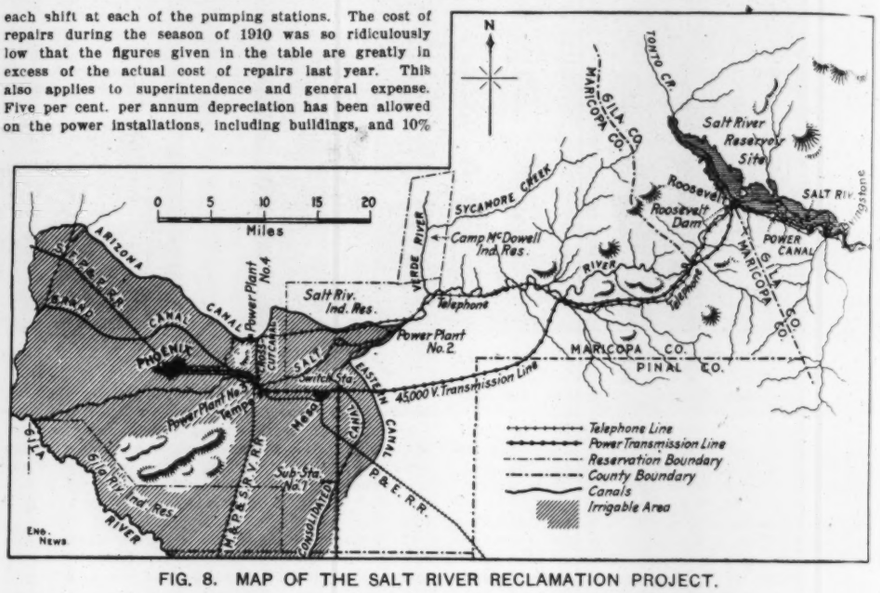


FIG. 8. MAP OF THE SALT RIVER RECLAMATION PROJECT.

TABLE II.—ESTIMATED MONTHLY OPERATING COSTS OF MINIDOKA PUMPING SYSTEM BASED ON ACTUAL COST DURING SEASON OF 1910 EXCLUSIVE OF DITCH TENDING.

	Power plant.	Pumping station No. 1.	Pumping station No. 2.	Pumping station No. 3.	Transmission line.	Total.
Capacity	6,500 KW.	575 sec. ft.	500 sec. ft.	325 sec. ft.	6,500 KW.	....
Labor	$700	$300	$300	$300	$100	$1,700
Supplies	150	30	30	15	5	230
Repairs	75	20	20	10	10	135
Superintendence and general expense	400	200	200	150	40	990
Depreciation	1,460	670	670	350	300	3,450
Total	$2,785	$1,220	$1,220	$825	$455	$6,500
Acre-feet pumped	.....	25,000	20,000	15,000	....	....
Acre-feet pumped 1 ft. high	.....	750,000	600,000	450,000	....	1,800,000
KW-hr.	3,600,000	1,500,000	1,200,000	900,000	....	3,600,000
Cost per acre-ft. 1 ft. high	0.154 ct.	0.163 ct.	0.203 ct.	0.183 ct.	....	0.362 ct.
Cost per KW.-hr.	0.77 ct.	.....	.....	.....	....	0.18 ct.
Cost per acre per season	.....	.....	.....	.....	....	78 ct.

Depreciation at 5% per annum on complete power installation; 10% on line.

Estimates for the six months of the irrigating season assuming that the winter operating expenses are covered by the sale of power.

Allows three acre-feet per acre during season over 50,000 acres.

Average lift 73 feet.

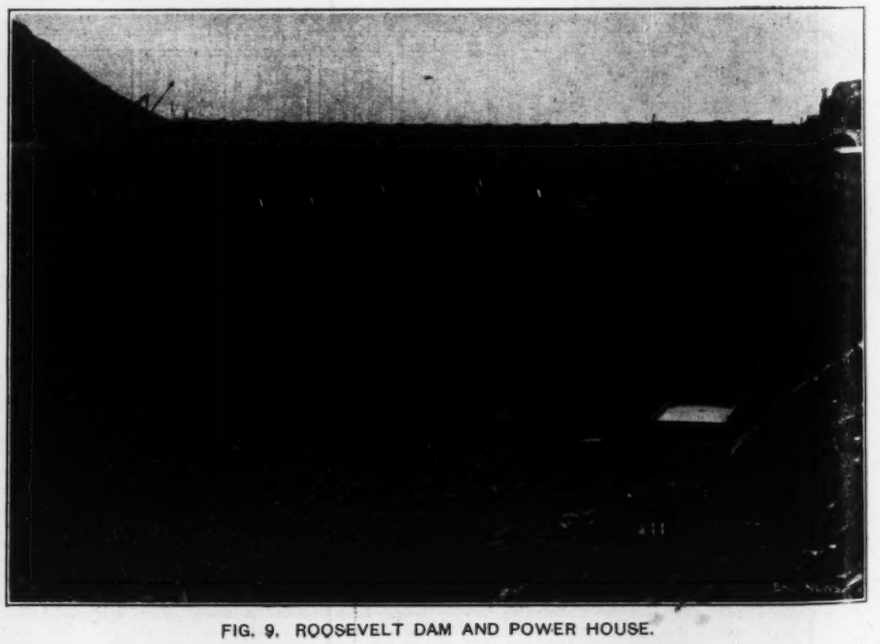


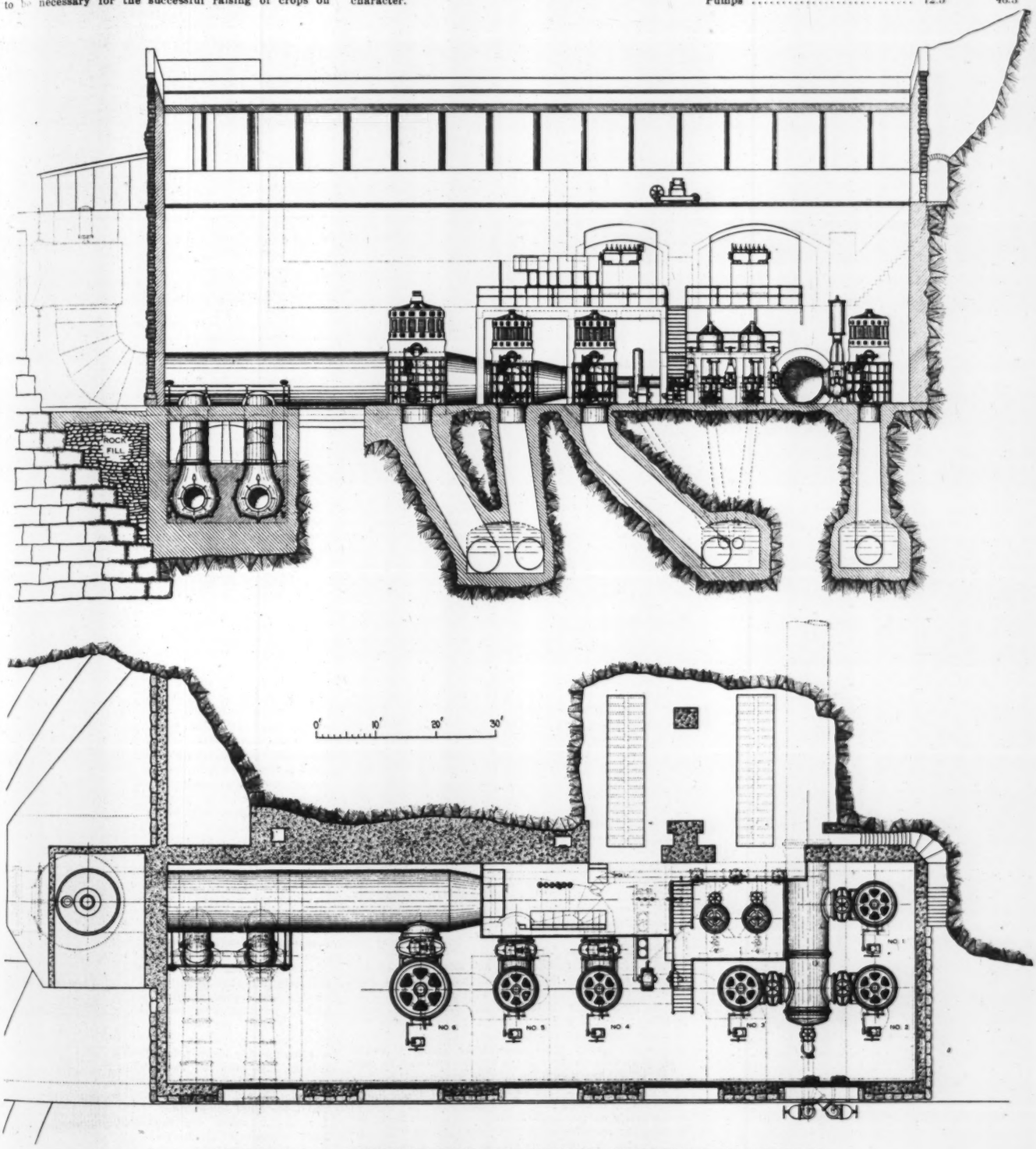
FIG. 9. ROOSEVELT DAM AND POWER HOUSE.

per annum on the transmission lines. No interest charge appears, since funds for the construction of all reclamation projects are, in reality, loaned by the United States to the settlers without interest.

The figures giving the acre-feet pumped by each station were arrived at by comparison of the installed capacity and the acre-feet pumped during the season of 1910 with the ultimate capacity of the various pumping stations and it is found that the figures thus obtained check very closely with the amount of water estimated to be necessary for the successful raising of crops on these lands; namely, three acre-feet per acre per season. The acre-feet pumped 1 ft. high was found for each station by multiplying the total acre-feet for that station by the approximate net lift, namely, 30 ft. The results of last season's run showed that the kilowatt-hours generated at the power plant were almost exactly double the acre-feet pumped 1 ft. high by the pumping stations; and since one kilowatt-hour is equal to 1.01 acre-feet 1 ft. high, this would indicate a working efficiency from power plant to water delivered in the upper canals of approximately 50%. This actual working efficiency should be compared with the accompanying table of full load efficiencies, starting with the water behind the dam and working through the system to the water delivered in the upper canals. The cost of operation per acre-foot pumped 1 ft. high, given for the various pumping stations, might be taken to represent what a company would expect to pay for operating expenses, exclusive of the cost of power in a pumping station of this character.

TABLE III.—FULL LOAD EFFICIENCIES.

	Efficiency, per cent.	Net efficiency from water behind the dam, per cent.
Turbines	81.5	81.5
Generators	96.0	78.2
Step-up transformers	98.4	77.0
Transmission line	90.0	69.3
Step-down transformer	98.0	67.9
Motors	94.0	63.8
Pumps	72.5	46.3



FIGS. 10 AND 11. PLAN AND SECTION OF POWER HOUSE AT THE ROOSEVELT DAM.

In the table of operating cost it has been estimated that the entire winter operating expenses, including fixed charges, will be covered by the sale of power and that the land under the pumping season will not be charged with any standby expenses for the winter season. In such a system as this, where a large amount of power is required during the summer irrigating season, and none during the winter season, the development of a winter load is very desirable, and with this in view, the transmission lines have been extended to the towns of the Minidoka Project and power is there sold for commercial purposes. Extremely low rates are offered for electric heating and the use of large amounts of power for all purposes during the winter is encouraged in every possible way. By furnishing power at very low rates, especially during the winter months, the annual operating and maintenance charges against the pumping system are reduced and the settlers on the project, who

FIG. 12. THE ROOSEVELT-PHOENIX TRANSMISSION LINE IN THE MOUNTAINS.

FIG. 15. EXTERIOR OF ONE OF THE WELL HOUSES, SALT RIVER PROJECT.

have paid for this work, have the benefit of cheap electric light, power and heat.

Salt River Project.

Transmission applied to irrigation on the Salt River Project is an entirely different problem from that on the Minidoka Project. On the Minidoka Project, the only method by which water could be obtained for 50,000 acres of the land was through the medium of the pumping system. On the Salt River Project a storage reservoir, diversion works and canals are constructed, prepared to irrigate about 260,000 acres of land by gravity and pumps. The pumping system will serve two purposes; one is to prevent the rise of the ground waters to a point dangerously near the surface, and the other is to supplement, by drawing on the underground supply, the

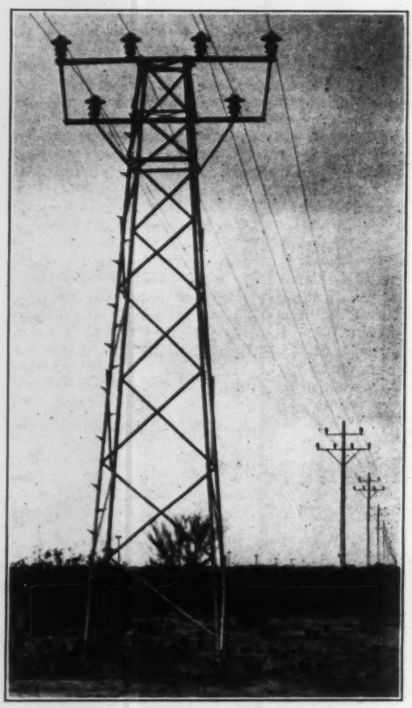


Fig. 13. A Stretch of the Roosevelt-Phoenix Line, In the Valley.

water stored in the reservoir and delivered by the natural flow of other streams.

POWER GENERATION.—The power development at the Roosevelt dam consists of two separate hydraulic developments, one from a power canal constructed to furnish power for building the dam, and ultimately for permanent power purposes; the other using the water from the reservoir as it is discharged for irrigation purposes. The first installation at the reservoir consisted of a turbine and generator in a cave excavated in the face of the cliff, a short distance below the toe of the dam. This cave is now used as a compartment for low-tension switch installation. In the early stages of the work this form of development was necessary on account of the heavy blasting in the vicinity and the consequent danger of damage to apparatus less securely housed.

Early in the construction work, however, plans were developed for a complete power plant, shown in Figs. 9 and 10. The power plant was constructed upon a rock foundation formed by excavation of the canyon side. The draft tubes and tail race tunnels are constructed in solid rock. The water from the power canal is brought to three of the units through an incline tunnel, lined half way down with concrete only, the balance of the way the concrete is lined on the inside with 5/16-in. steel plate. Extending from the lower end of the tunnel the seven-foot penstock is made up of 5/16-in. butt and strap-riveted steel plate and is connected to three units capable of being operated continuously at 1,200 KW. The static head is 226 ft. On account of the heavy rock excavation necessary to get sufficient room for the building, economy of space was an important consideration in the design of the plant. This led to the selection of the vertical types of generating unit shown in the illustrations.

The second development is a 10-ft. penstock through the dam, controlled with a large cylinder gate just outside the power-house. To this penstock will be connected three units, one of them of 2,000-KW. and the others of 1,200-KW. capacity. The operating head for which these turbines are designed to give the maximum efficiency is 160 ft. and it is expected that they will be controlled to operate at heads ranging from 90 to 220 ft. The reservoir contains above the 110-ft. level, 90% of its full capacity. It may, therefore, be seen that when the reservoir gets below 160 ft., while the power of the wheels will fall off greatly, the total amount of energy that is available in the reservoir is not great.

The generating units operate three-phase, at 300 r. p. m., 25 cycles, 2,300 volts. The efficiency at full load and 100% power factor, is 95%; the regulation at 100% power factor is 8%; and the temperature rise at full load is 35° C.

There is a double bus-bar switchboard with selector switches for both transformers and generators. These switches are located in the power-house and are controlled by a benchboard. The transformers and high-tension switches are located in a separate building, about 600 ft. from the power plant. The transformers rest on large castors and are in fireproof compartments, each three-phase group being isolated by concrete barrier walls. Switches and bus-bars are all enclosed in concrete cells. The transformers have a nominal capacity of 350 KVA., but have shown such good regulation and low heating characteristics that they may be operated continuously at nearly double this capacity without exceeding the temperature limits of the Institute standardization rules. There are six groups of these transformers, transforming from 2,300 volts delta to 45,000 volts star, the potential of transmission.

TRANSMISSION.—The transmission line consists of six 83,000 circular-mil, six-strand, hard-drawn copper wires, supported on 14-in. insulators having a flash-over test of 165,000 volts, dry. The line is supported on steel towers with the lowest wire at an average elevation of 30 ft. from the ground in the mountains, and a limiting distance of 30 ft. from the lowest wire to the ground in the valley. The towers average a distance of 360 ft. apart in the mountains, on account of rough country, and 400 ft. apart in the valley.

This line is 65 miles long, reaching to Phoenix, the largest town on the project. A branch line taps off from a four-way switching station 40 miles from the power-house, near the town of Mesa and runs south 20 miles terminating in a substation at the Pima Indian Reservation. There is also, about 10 miles south of the main line, another substation for general irrigation pumping. It is contemplated that in the future practically all the power of this plant will be used for irrigation purposes, although at the present time it is supplying the local distributing company in Phoenix with power under modification of an old contract, in effect before the Reclamation Service commenced work.

After the line reaches the cultivated district, the tripartite form of steel pole is used instead of steel towers, on account of the ground space that was saved by such use. Thirty miles of this line was exceedingly difficult to construct. In some places the wire had to be drawn through by cables for nearly three miles, as it was inaccessible by the road. The line was constructed by pulling the wire under tension by means of a steel hauling line over sheaves placed on the cross arm. The cost of 65 miles of two-circuit line was $4,400 per mile.

The main transmission line of this system has given absolutely no trouble since the day it was started, from any cause that can be traced to the line itself, that is, failure of insulators, towers or similar causes. Shortly after the line was put into operation, however, it developed that large hawks, which exist in great numbers in the plain adjacent to the cultivated area, covering about 18 miles of the main line, caused frequent interruptions by alighting on the towers and short circuiting the wires with their wings. The local superintendent has overcome this by installing on the cross arm a small casting provided with sockets, in which are rods of hard wood projecting upwardly, forming sharp points between the insulators. These are very effective and have entirely stopped the trouble. The large birds are extremely careful about injuring their wings or themselves in lighting near any such device. The same thing occurred on the branch line recently constructed and this remedy was applied.

One section of the irrigation development by pumping is about completed. This is 12,000 acres of land, to be

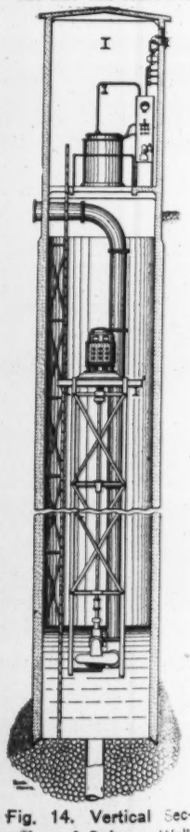


Fig. 14. Vertical Section of Caisson Well, Salt River Project.

supplied almost wholly by pumped water, on the Pima Indian Reservation at Sacaton, near the Gila River. There is a flood ditch which will supply water from the Gila when it may be in flood. This is a very erratic stream and cannot be depended upon, but its waters are useful in supplying fertilizing qualities to the soil, since it carries a vast amount of silt and dissolved valuable fertilizing material. In the main, however, these 12,000 acres of land will depend upon the pumps. A line of wells was located, about two miles from the Gila River, slightly diverging towards the north from the river. These wells consist of first, a 16-in. California well casing driven to a depth of 200 ft.; a large portion of this depth was found to be of coarse gravel. Around this was sunk a concrete caisson, 9 ft. in diameter, to a depth of 45 to 55 ft. In sinking these caissons a pump having a capacity of 12 second-feet was used, and when a depth was reached which corresponded to the capacity of that pump, to keep the pit dry for excavating purposes, the work was stopped. The top of the caisson was then finished into a small square building for the installation of apparatus. Motor, transformer, pump, etc., were installed as shown in Fig. 14.

The specifications for this pump required a maximum efficiency at five second-feet and 55 ft. lift, of 70%, and at 35 ft. lift and a correspondingly increased capacity, an efficiency of 63%. In the effort to meet these conditions on a flat-top efficiency curve so the motor would not be overloaded at lower heads, the manufacturer obtained a pump giving exceedingly fine efficiency, namely, 80.6%, including the suction elbow and discharge elbow, at 5.5 sec.-ft. and 55 ft. lift.

The pump is a top-suction, vertical-shaft pump, carried between galvanized steel channels forming a frame, which carries a suitable number of cast-iron supports and guide bearings. The guide bearings have a pan case on the top to receive hard oil. At the top of the pump shaft is an oil-lubricated thrust bearing in action only as the pump is started. As soon as a small head of water is produced by the pump, a portion of the area of the bottom of the impeller becomes a thrust bearing, which as it starts to lift the impeller, uncovers openings from this thrust area in to the center of the volute, and the opening of these passages balances the pump and stops the impeller in proper alinement with the volute, thus carrying the weight of the impeller and shaft always on a water thrust.

This water thrust is adjustable by means of a plug attached to a lever and rod leading up to the motor base. A cast-iron base for the motor is fastened to the top of the frame by bolts. The top of the vertical shaft is fitted with a jaw coupling. The motor is placed on the cast-iron base with the other half of the coupling on the motor matching into the one on the pump shaft and bolted in this position. The jaw coupling allows vertical movement of the pump shaft as above described. The motor itself has an independent oil-lubricated thrust bearing.

Ball bearings are not sufficiently reliable for an installation of this kind, for the breakage of a ball, with the attendant ten miles away, would have serious consequences. Some form of bath bearings is best adapted to this work. In this case the bearing consists of large cast-iron collars furnished with a slight oil pressure from a small gear pump located in an oil reservoir holding several gallons of oil and placed at the top of the motor.

The whole mechanism of motor, pump and frame rests on I-beams, grouted in the concrete of the caisson. The motor can be unbolted and lifted out and the frame and pump then lifted out independently for examination. The discharge pipe is composed of galvanized riveted iron pipe hung in the caisson in the same way as the motor and frame. The remainder of the electrical equipment consists of 10,000-volt oil switches, a 10,000 to 220-volt, three-phase, self-cooled transformer, provided with taps for starting the motor at half voltage; a double-throw, triple-pole knife switch and an ammeter.

Ten of these units in a line ten miles long, and a 750-KW. substation, with provision for extension to 1,500 KW., are taken care of by two men, one an Indian. The pumps run with very little attention. Similar motors on another installation have operated for two years without giving any trouble whatsoever. Similar installations of pumps the writer has known to operate for long periods, with very little attention.

This pump running submerged is always working at its best efficiency. By using a large pump to sink the caisson all the fine material is drawn out of the gravel in the vicinity of the bottom of the caisson and no more sand will be drawn into the well at the reduced capacity of the permanent pump.

Operation to date has given an average minimum discharge of 6 sec.-ft. for each well, which corresponds to a lift of approximately 50 ft. and a pump efficiency of approximately 80%, as will be seen by reference to the test curves of the pump.

The whole pumping system is an exceedingly reliable one. Practically the only attention which seems to have been found necessary to date is the restarting of the pumps after an interruption. It is proposed that this may be finally solved for each group of this kind by starting them all from the substations by means of a compensator in the substation itself connected in the 10,000-volt circuit distributing to these pumping plants.

Taking this plant as it stands, solely as a pumping development, without the flood canal, in which case the area supplied would be limited to 10,000 acres instead of 12,000 we find some interesting results, as to cost, and it is believed that these results can be improved upon in the next installation of this character, by taking advantage of the experience gained in the sinking of caissons in this installation. Probably a saving of 15 to 20% might be made on that portion of the work. The cost of the ten wells and pumping equipment is $105,000, or about $10 an acre for the 10,000 acres which they will supply. Assuming that a power company stands ready to supply the current to the 10,000-volt line in regular commercial work, the following interesting results of cost of irrigation by this method may be deduced.

The power input to the pump at any head which will probably be maintained in these wells will not exceed 44 HP. Taking into account shaft losses, piping losses and loss in efficiency of the pump as time goes on, it may be assumed that 50 HP. applied to the pump is a reasonable figure. The load or the substation calculated from the proven efficiency of operation and line would be then 460 KW. supplied to the 10,000-volt line feeding the pumping station.

Assuming that it is necessary to run this system an average of 200 days a year, 24 hours a day, the installation will consume 2,208,000 KW.-hrs. To an installation of this size it may be assumed that power can be supplied from a water-power plant at not more than 1.5 cts. per KW.-hr., making a total cost for 10,000 acres of land $34,000 per annum, for power, or $3.40 per acre per annum for the 10,000 acres. Taking into consideration the climate existing in this locality and the soil which this water will supply, this is an extremely reasonable irrigation power charge.

The actual method by which the charge for power will be made to this particular pumping circuit, however, is that there will be charged against this section of land a sum representing the cost of the final development of power set aside to supply this pumping system for the Indian Department when it is all completed, and this pumping area will then pay the actual cost of furnishing such power. This will reduce the power cost to about one-third of that estimated above. So far as depreciation, renewals, repairs and attendance is concerned, it without doubt will compare well with any system of its kind heretofore constructed. The wells themselves are of a character which will probably last indefinitely. The equipment is one which it is believed will present a minimum of repairs.

Under the above assumption of operation, there will be 24,000 acre-ft. of water lifted an average of 50 ft. at a cost for power of $34,000, or at a cost of $1.42 per acre-ft., making $0.0285 the cost per acre-ft. 1 ft. high, which is the figure upon which comparison should be made with other installations as to power cost.

In regard to the Salt River Project, it is expected that there may be over 100 pumping plants similar to these described in the Pima Indian Reservation constructed. These will serve the purpose of drainage as well as add to the irrigated area. The power for these plants will be furnished, of course, at cost, as the operation of the pumping season will be a part of the project.

This brief description of these two installations, covering two types illustrating the subject under discussion, represents only a portion of the work of this character which is being carried on by the Reclamation Service. There are many complex and interesting problems connected with the various projects, for which there is no space in this paper.

A Column Failure Which Wrecked a Gas-holder.

On the afternoon of Dec. 7, 1909, a gas-holder of 7,000,000 cu. ft. capacity, of the municipal gas works in Hamburg, Germany, collapsed while filling with gas, the bell being just about to engage the second lift. The outflowing gas ignited. Twenty persons were killed. The holder was new, and had been in service for only a week or two.

An expert investigation of the accident was made, and recently the gas committee of the city council reported the results. We noted the conclusion in our issue of May 25, 1911, p. 632, to the effect that one of the columns supporting the holder floor gave way, so that the floor collapsed; and that the failure of the column resulted from faulty design. A somewhat fuller report in "Stahl und Eisen" of June 1 enables us now to give some details. It is stated there that while the experts reported that the column was too weak, in consequence of designing by the Euler formula, yet there was not sufficient departure from recognized methods to warrant a criminal negligence charge. No prosecution will be started.

The gas-holder floor was elevated to allow coal cars to be run through below. Steel trusses supported it, their outer ends being carried by a stone wall with suitable openings for traffic, while the middle was supported by a group of steel columns. One of the compression members of this supporting framework failed; it is not clear from the account whether a column or one of the truss members is meant.

The bottom gave way, the gas flowed out and ignited, and a tremendous flame spread over the neighborhood. The bell of the holder, after twice rising again for a height of a few meters, dropped rapidly; in a few seconds the destruction was accomplished.

It seems that in the examination of the ruins, buckled compression members were found among the wreckage of the bottom framework. These struts were composed of two channels, connected only by tie-plates at intervals. At least one of them showed torn tie-plates and sheared rivets, which indications presumably led to attributing the primary failure to a particular strut.

The ruptured member in question was 11.1 ft. long, c. to c. of end connections, and was designed to carry a maximum compression of 118,000 lbs. The city's expert estimated that at the time of collapse it may have borne a load of 133,000 lbs., taking account of all unfavorable circumstances.

This strut consisted of two 6.3-in. channels (German standard channel No. 16) back to back, 1-in. apart. The combined sectional area of both channels was 7.4 sq. ins. They were not latticed, but merely tie-plated at intervals of 40 ins., by plates 6 × 5/16-in. by 5½ ins. long; these plates were attached by four 13/16-in. rivets. If the column section be assumed to be integral, its least radius of gyration is 1.44 ins.; the least radius of a single channel is 0.74-in.

It may be noted that the mean load per square inch of section at the time of failure was just 18,000 lbs. per sq. in., according to the expert's assumptions, or 15,900 lbs. per sq. in., according to the designer's assumptions.* In connection herewith, the length conditions must be remembered: For the length between tie-plates (38 ins. clear), l/r for one channel was 51. For the whole length of the strut, considering the section as integral, the value of l/r was 93. Any partial fixity due to the end connection would reduce the latter ratio, but as the tie-plated aggregation is very much less rigid than a truly integral section the equivalent l/r was doubtless much greater.

The designer, it appears, proportioned by Euler's formula, as follows: Taking the full length as free, but considering the section as integral, the buckling load is found from this formula as 260,000 lbs., or about 35,000 lbs. per sq. in. But the designer figured on end constraint, and used in the formula only seven-tenths of the actual c. to c. length; by this change, the buckling load from the formula is multiplied by $(10/7)^2$, or is practically doubled, giving an apparent total capacity of 520,000 lbs., i. e., a strength of 70,000 lbs. per sq. in. A factor-of-safety of 4 was sought for, and the above ridiculous result was interpreted as showing that this factor was obtained.

However, numerous specifications in Germany, governmental and others, prescribed or permit the use of the Euler formula; also, the use of tie-plated columns, rather common in German practice, is not prohibited by most specifications. Prof. Müller-Breslau, who reported on the accident for the builders of the gas holder, says in his report that the use of the Euler formula in connection with the use of tie-plated columns, when the section is assumed to be integral, may lead to constructions which do not afford adequate security under loading of unusual character.

*The average load on the compression member or members which wrecked the Quebec Bridge is stated in the Report of the Royal Commission as 16,800 to 17,900 lbs. per sq. in. The coincidence with the above figures is interesting.

Experimental Studies of the Electrolytic Destruction of Reinforced Concrete.

At the recent convention of the American Institute of Electrical Engineers, held at Chicago, June 26-30, a discussion of the paper on "Electrolytic Corrosion in Reinforced Concrete,"[1] of Messrs. C. E. Magnusson and G. H. Smith was presented by Mr. Harry Barker, of New York City, and Prof. W. L. Upson, of Burlington, Vt., giving the results of two series of tests carried on at the University of Vermont in the past year.[2]

These experiments were planned to throw light particularly on the mechanism of rupture of reinforced concrete due to electrolysis, and on the actual seat of the stresses causing rupture.

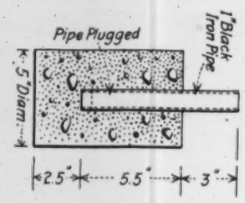


Fig. 1. General Type of Test Blocks for Qualitative Study on the Electrolytic Destruction of Reinforced Concrete.

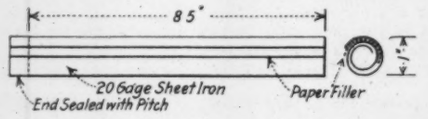


Fig. 2. Collapsible Iron Electrode.

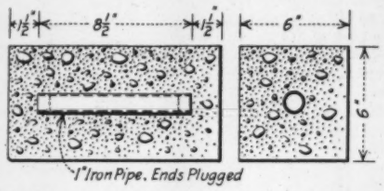


Fig. 3. Specimen with Completely Imbedded Electrode.

It will be recalled that Mr. U. J. Nicholas described, in Engineering News, Dec. 24, 1908, experiments made at the Massachusetts Institute of Technology in which it was found that specimen blocks with imbedded iron electrodes could be cracked irrespective of direction of current, that is with the imbedded iron as either anode or cathode. These tests added a little information in as much as they indicated that the cracking of the concrete might perhaps be due to either electrolysis or localized heat.

Prof. A. S. Langsdorf, of St. Louis, in 1909 (see Eng. News, April 29, 1909), added corroborative knowledge by finding progressive corrosion of the imbedded iron, soft disintegration of the concrete and dissemination of iron oxide through cracks.

Messrs. Eltinge and Beers, in Engineering News, March 31, 1910, described experiments made at the Rensselaer Polytechnic Institute in which they duplicated by heat the cracking and soft disintegration of electrolysis.

The experiments of Messrs. Magnusson and Smith at the University of Washington (Eng. News, June 8, 1911) were directed towards obtaining the electrical resistance of various mixes, wet and dry, and toward the test of specimens with which the imbedded iron had been variously "protected" against the action of current. The iron was covered with red lead in linseed oil, graphite paint, various sorts of varnishes, and zinc and aluminum coatings. It was found that, with the various paints whose purpose was largely to interpose an impervious or insulating membrane between the iron and concrete, the membrane eventually became porous when the specimen was immersed. Zinc offered no protection, but aluminum paint acted in much the peculiar way that a layer of metallic aluminum might have been expected; that is, it caused a considerable diminution of current, but this gain was only temporary. No practical remedies were developed.

One series of the University of Vermont tests was intended to be entirely qualitative and to use the studies already mentioned as points of departure. The particular features of novelty are seen in the make-up of the specimens: (1) Collapsible iron electrodes, shown in Fig. 2, were used with the idea of showing if thermal expansion, or the crowding of iron oxide at the electrode surface, would crush the electrode instead of cracking and softening the concrete; (2) imbedded carbon electrodes were used in one set of blocks for studying the action under conditions where iron and iron oxide could not be present; (3) loose carbon electrodes were used to eliminate with these still another possible source of trouble; that is, the development of mechanical force at the electrode surface; (4) duplicates of these different types of blocks were subjected to alternating current, keeping all conditions the same except as to the kind of current; (5) special blocks were subjected to thermal stresses according to the temperatures actually noted in the other trials where cracking occurred.

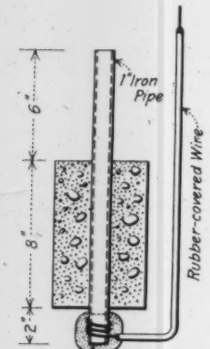


Fig. 4. Thermal-Test Specimen.

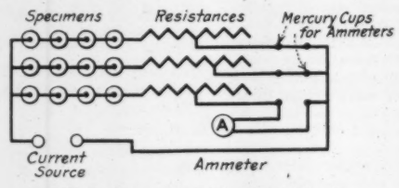


Fig. 5. Diagram of Electrical Circuits.

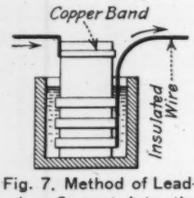


Fig. 7. Method of Leading Current Into the Specimens with Completely Imbedded Electrode.

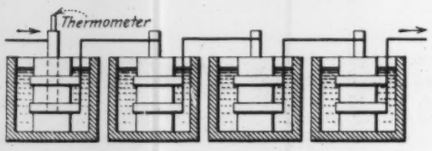


Fig. 6. Arrangement of Immersed Specimens.

The Portland cement used was the "Ironclad" brand. Tests for fineness showed 23.80% left on a 200 sieve and 5.85% left on a 100 sieve. The specific gravity was 3.11. The breaking strengths of standard briquettes were as follows:

Days age.	No. 1.	No. 2.	No. 3.	Average.
Neat-Cement:				
7	480	550	588	539
28	625	645	667	646
1:3 Sand-Cement Mortar:				
7	90	95	107	97
28	185	190	103	159

The low breaking strength of the mortar has been explained by the excessive dryness of the sand used. This sand was of uniform size, passing through a 10-mesh and remaining on a 30-mesh screen. The broken stone was a gray sandstone in ½-in. pieces.

The concrete for the blocks was a 1:2:4 mix. The electrical circuits were as shown in Figs. 5 and 6. Each group of Fig. 5 contained one of each type of block. Two duplicate tests were made simultaneously, one with alternating and one with direct current, both of a value of 0.1 amp. A small generator set was used for the direct-current supply and the city lines were drawn on for alternating current; adjustments were made several times a day to hold the current constant. The special specimens shown in Fig. 4 were tested simultaneously with the others; they were placed in water as in the straight electrolysis runs, but current was confined to the metallic circuit and regulated as to secure the same temperature of a thermometer in oil in the pipe as was found in the electrolysis runs.

For convenience and simplicity, the results of tests with the separate types of blocks are summarized separately.

IMBEDDED PIPE ELECTRODE. — These blocks behaved quite in accordance with previous experiments. When current was first turned on there was an apparent washing out of some cement-like material with a free evolution of gas at the imbedded electrodes. After 24 hours a considerable amount of iron oxide was forced out around these electrodes and in a few days the entire top of the blocks was covered with "rust." Gases were thrown off, throughout the experiments, from all parts of the concrete. The temperatures varied only slightly from 22° C.

The apparent resistances of all specimens were measured by the voltmeter-ammeter method. The typical results of one set are plotted in Fig. 8. The gradual increase of "apparent" resistance shown may be explained variously as due to the accumulation of iron oxide which decreased porosity, to accumulated gas or to some chemical change in the cement of the concrete. It seems reasonable that the iron went into solution as a hydrate and was later converted to oxide by the oxygen electrolytically evolved and perhaps by the cement compounds themselves. If the last oxidizing action was very general, it might be expected to diminish the strength of concrete. Should the action, if any, be confined to the neighborhood of the electrode, there might be no appreciable change in the general strength of the block. The sharp peak shown in Fig. 8 suggests the beginning of rupture.

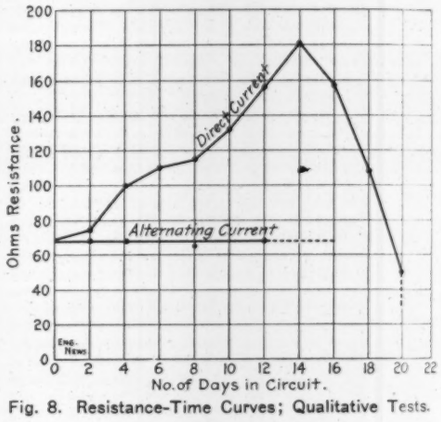


Fig. 8. Resistance-Time Curves; Qualitative Tests.

One specimen on direct current showed distress at the end of 20 days, the first indications being the appearance of small drops of rusty water on the top of the block. These places developed into cracks along which the blocks broke. The concrete could easily be broken with the fingers and the iron was much corroded; rust was disseminated throughout the concrete, especially along the lines of failure.

Blocks subjected to alternating current did not break at all at low current, nor was there any corrosion of the electrode under any conditions. The general appearance and strength of the concrete were unchanged. No gas was liberated by the alternating current.

At the completion of the ordinary runs, alternating current of up to 3 amps. was used. The internal temperature increased to 45° C. and the blocks split after eight to ten hours. Typical ones are shown in Fig. 11 after having been broken apart with a hammer. The specimens with various solid imbedded electrodes behaved similarly, all splitting apparently from the same cause.

[1] Described in Engineering News, June 8, 1911.

[2] The two series were planned by the authors of the discussion and were carried out (under their general direction with the assistance of Prof. J. W. Elliott) by Messrs. O. J. Olgiati and H. Roberts, senior students in the Departments of Electrical and Civil Engineering, at the University of Vermont, as their bachelor thesis.

COLLAPSIBLE IRON ELECTRODES.—The blocks having collapsible iron electrodes, used on direct current, were the second to break. This delay is explained as being due, in a small measure, to the slightly larger diameter of electrode and, to a much greater degree, to the yielding of the collapsible electrode to the demand of the oxide for room. The final disruption is explained as being due probably to stresses set up by the formation of iron oxide in the pores of the concrete a short distance in from the anode. On alternating current, the collapsible-electrode specimens showed no signs of distress. The blocks did not split and the concrete was not softened on increasing the alternating current to 3 amps.

Fig. 9. Specimens with Iron-Pipe Electrodes; After Rupture on Direct Current.

Fig. 10. Specimens with Collapsible Iron Electrodes; After Rupture on Direct Current.

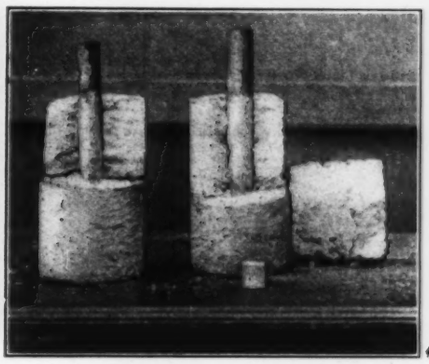


Fig. 11. Specimens with Iron-Pipe and Collapsible Electrodes; After Tests on Alternating Current.

IMBEDDED CARBON ELECTRODES.—A surprising result of these experiments was the splitting of blocks with carbon anodes, under direct current. In place of the iron oxide of other specimens, a thick black mush was forced out around the anode. This was evidently some obscure combination of carbon and some ingredient in the concrete, although the actual composition of the material was not reported. The carbon anode was eaten away and there was an appreciable dissemination of the black mass in the concrete, as shown in Fig. 12. The increase of resistance of these specimens was not as decided as in the cases of the iron anode. Cracks were developed in 25 days and the mass of concrete was appreciably softened, though not as much as in tests with iron anodes. On alternating current, no signs of damage were reported; the electrode was unchanged and the concrete unsoftened.

Fig. 12. Specimen with Imbedded Carbon Electrode; After Rupture on Direct Current.

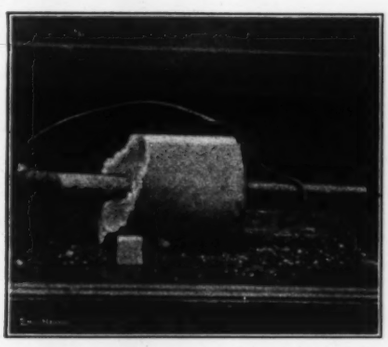


Fig. 13. Thermal-Test Specimen; Broken Open After Electrical Tests.

Fig. 14. Specimens with Loose Carbon Electrodes; Broken Open After Direct-Current Tests.

Fig. 15. General Type of Specimen for Quantitative Experiments on Electrolytic Destruction of Reinforced Concrete.

LOOSE CARBON ELECTRODES.—With direct current, gas was freely evolved at the loose carbon anode, with a decided odor of chlorine, though it is reported that no chlorides or other chemicals were added to the water. The same black compound was formed and the anode was deeply pitted. After four weeks' run, however, no disintegration of the concrete could be found. At the end of this time the current was raised to 1 amp. for 12 hours, but without apparent effect. The blocks were then broken open with a hammer and appeared as shown in Fig. 14. On alternating current no ill effects on concrete or carbons were noted.

COMPLETELY IMBEDDED IRON.—An attempt was made with the specimens shown in Figs. 3, 7 and 16 to simulate actual construction conditions where random voltages might not be actually applied to the reinforcing steel. Fig. 7 shows the method of leading current through the block. After 18 days with 0.1 amp., direct current, the block split, showing typical corrosion of iron and spread of oxide. The specimen used with alternating current was unaffected. Both specimens are shown in Fig. 16 after test, the one used on alternating current having been broken open with a hammer.

THERMAL-TEST BLOCKS.—As already noted, the pipes in these blocks were kept at the observed temperature of the iron in the blocks subjected to direct current. The temperatures varied but slightly above those of the room and the specimen remained sound. On breaking open these blocks at the end of the runs, the pipe was found to be not rusted.

QUANTITATIVE SERIES OF TESTS.—Sets of 22 smaller blocks, with each of the four types of electrodes mentioned, were made up to be given the treatment previously outlined, but to be broken in a testing machine progressively at regular intervals so as to find whether the destructive actions were suddenly or gradually developed. A 1:2 cement sand mortar was used, the cement and sand being those already noted. Fig. 15 shows the general make-up of the blocks, the only difference being in the electrodes. The blocks were immersed for three weeks before use. In addition, 20 dummy blocks were made without electrodes and tested under the same conditions except as to current.

At the start, two blocks of each type were crushed in an Olsen machine, and at regular intervals as the electrolytic runs progressed two more of each type were crushed. The iron-pipe electrodes were weighed before being placed in the blocks and after breaking. This gave an easy determination of the loss of iron by corrosion. Uniform loading of the blocks was secured in the testing machine by using ¼-in. of blotting paper between the block and the jaw and table of the machine. Load was applied at right angles to the electrode axis. Results of these tests are shown in the accompanying table. The electrical circuits were as in Figs. 5 and 6.

CONCLUSIONS.—The following tentative con-

FIG. 16. SPECIMENS WITH COMPLETELY IMBEDDED ELECTRODES.
(At the right, direct-current specimen; alternating-current at the left.)

RESULTS OF QUANTITATIVE TESTS ON ELECTROLYTIC DISINTEGRATION OF REINFORCED CONCRETE.

Iron-pipe electrode.					Collapsible iron electrodes.			Solid carbon electrodes			Loose carbon electrodes.		
No. specimen.	No. hours in circuit.	Aver. loss per day, grams.	Breaking load of specimen.	Breaking load of dummies.	No. of specimen.	No. hours in circuit.	Breaking strength.	No. of specimen.	No. hours in circuit.	Breaking strength.	No. of specimen.	No. hours in circuit.	Breaking strength.
0a.....	0	0	20,100	.....	0b.....	0	14,400	0c.....	0	30,000	0d.....	0	14,8[illegible]
1a.....	66	.215	19,600	18,070	1b.....	66	14,230	1c.....	66	22,700	1d.....	66	15,0[illegible]
2a.....	66	.175	18,680	.....	2b.....	66	12,910	2c.....	66	19,630	2d.....	66	18,0[illegible]
3a.....	138	.202	19,550	17,900	3b.....	138	13,670	3c.....	138	25,120	3d.....	138	18,5[illegible]
4a.....	138	.178	18,750	.....	4b.....	138	12,800	4c.....	138	25,740	4d.....	138	16,9[illegible]
5a.....	186	.194	19,600	20,900	5b.....	186	14,250	5c.....	186	24,250	5d.....	186	22,0[illegible]
6a.....	186	.195	24,200	.....	6b.....	186	10,000	6c.....	186	23,800	6d.....	186	19,0[illegible]
7a.....	282	.202	20,800	20,320	7b.....	282	14,72[illegible]	7c.....	282	24,340	7d.....	282	18,4[illegible]
8a.....	282	.182	19,950	.....	8b.....	282	13,87[illegible]	8c.....	282	21,700	8d.....	282	17,1[illegible]
9a.....	354	.197	22,630	24,325	9b.....	354	14,80[illegible]	9c.....	354	23,200	9d.....	354	18,1[illegible]
10a.....	354	.203	22,740	.....	10b.....	354	10,4[illegible]	10c.....	354	17,650	10d.....	354	15,5[illegible]
11a.....	426	.211	19,860	23,500	11b.....	426	12,5[illegible]	11c.....	426	18,350	11d.....	426	16,8[illegible]
12a.....	426	.214	10,200	.....	12b.....	426	12,570	12c.....	426	24,000	12d.....	426	15,4[illegible]
Test stopped for three days.					Test suspended for three days.			Test was stopped for three days.			Continuous Test.		
13a.....	498	.210	28,710	25,980	13b.....	478	15,590	13c.....	498	33,500	13d.....	498	19,2[illegible]
14a.....	498	.198	26,110	.....	14b.....	478	14,900	14c.....	498	32,100	14d.....	498	15,3[illegible]
15a.....	570	.197	30,450	27,010	15b.....	570	17,370	15c.....	570	37,250	15d.....	570	12,6[illegible]
16a.....	570	.176	28,350	.....	16b.....	570	19,100	16c.....	570	29,250	16d.....	570	12,4[illegible]
17a.....	642	.223	20,500	31,300	17b.....	642	18,300	17c.....	642	30,300	17d.....	642	19,4[illegible]
18a.....	642	.190	20,600	.....	18b.....	642	18,200	18c.....	642	26,100	18d.....	642	16,7[illegible]
19a.....	744	.194	36,000	31,245	19b.....	744	12,500	19c.....	744	24,500	19d.....	744	19,7[illegible]
20a.....	744	.188	27,740	.....	20b.....	744	15,800	20c.....	744	31,700	20d.....	744	17,6[illegible]

clusions regarding the seat and mechanism of electrolytic disruption were presented, with the caution that these were only tentative and did not in any way effect recognized practical measures which might be undertaken to prevent conditions leading to the structural failure of reinforced concrete.

(1) The disruption of reinforced concrete may result from stresses produced by local thermal expansion, where the current density is high, with either alternating or direct current and irrespective of the direction of current in the latter case.

(2) With small current densities, without temperature stresses being developed, disruption finally results from the accumulation of iron oxide at and near the imbedded iron where direct current leaves the iron to enter the concrete.

(3) The bursting stresses developed with low current densities are largely caused by the formation of the iron oxide immediately at the anodic surfaces, to a slight extent, but largely in the concrete near the anodes, the depth of penetration depending on the porosity of the concrete, on the gas pressure, current strength, etc., among other things.

(4) No gradual reduction of the strength of the concrete has been shown to accompany progressive corrosion of the iron. The oxygen for the formation of oxide probably is furnished mostly by the electrolysis of water and only to a slight degree is taken from the cement compounds.

(5) Disruption of concrete may result with low current densities, where iron is not the anode material, if other compounds are formed from the anode or from the concrete and expand during the secondary reactions. In all cases, pressure of gases developed may slightly assist or hasten disruption.

(6) The general softening of the concrete after rupture is similar to that in specimens crushed mechanically and may be here regarded as largely the result of the bursting stresses.

(7) A single current of small density may cause corrosion and disruption at several points by passing to and from a number of pieces of reinforcing steel, each completely imbedded.

(8) With large leakages of either direct or alternating current to reinforced concrete, structural failures may be expected within a few hours of the start of current, and as the result of thermal effects.

(9) With small leakages of direct-current an insidious undermining of mechanical strength must be expected.

(10) With alternating currents, when the current density is low enough to eliminate local temperature stresses, repeated tests have shown no danger of structural troubles. This is in accord with the findings reported by Mr. J. L. R. Hayden, before this Institute, March, 1907.

(11) Structural trouble is not to be expected with dry concrete unless random high direct-current voltages are noted on the structural members.

(12) Present methods of electrical surveys seem sufficient to detect dangerous (to the structure) voltages about reinforced-concrete structures, and remedies are available for application as each individual case seems to demand.

A Relieving Rail Joint for Track Scales and Turntables.

At track scales and turntables, the open joints between the rails on the approach and those on the table usually cause a heavy shock to the table as the wheels cross the joint and throw the load upon the table. Such action tends to result in strain of the working parts and to excessive wear of the scale mechanism. In certain cases, the scale table has been made with one side (and one rail) longer than the other, so that both wheels will not come upon it simultaneously.

A rail joint which has been designed to overcome the objectionable sudden loading or impact is based on the idea of carrying the wheel across the gap by an easer or relieving rail which engages the outer edge of the wheel tread. This is a bar of manganese steel, having its upper surface about 3/16-in. above the level of the rail head; the ends of the bar are inclined. The construction as applied to a large track scale is shown in Figs. 1 and 2. The rail head is planed away on the outer side of both rails, and the easer is secured to the approach rail by six bolts; its shorter end is alongside the rail on the scale table, but is not in contact with it and is not attached to it in any way. The wheels are raised slightly, carried over the gap, and take a bearing upon the scale rail a little distance beyond the joint. In the half-tone engraving, Fig. 2, it will be noted that the line of wear on the approach rail (at the left) indicates the vertical movement of the wheel, while on the scale rail (at the right) the line of wear is very faint from the rail end to the point at which the wheel is returned to its full bearing on the rail. The rail in which no joint is shown is the dead rail used by cars which cross the scale without being weighed.

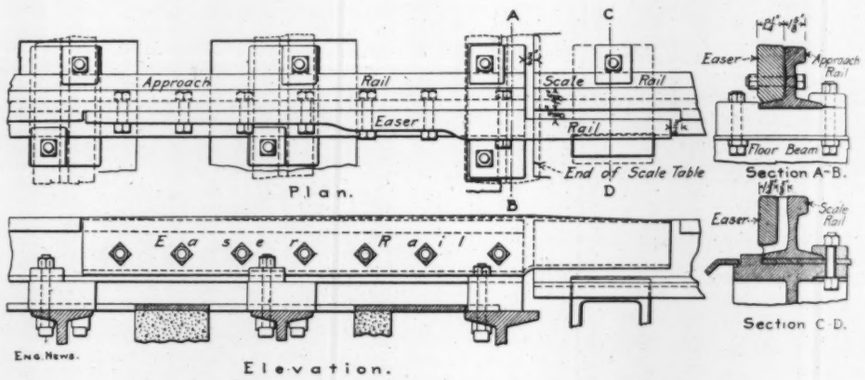


FIG. 1. RELIEVING RAIL JOINT FOR TRACK SCALE CONNECTIONS.

The device described is known as the Bohannon-Dugger easer rail, and for information concerning it we are indebted to Mr. Neal Dugger, Scale Inspector of the Tennessee Coal, Iron & Ry. Co., of Ensley, Ala. It is adaptable also for turntables, swing bridges or lift bridges, but for the two former cases it would have to be pivoted (or otherwise movable) so as to be clear of the rails when the structure is swung. A somewhat similar arrangement is used at the expansion joints on the Thebes Bridge (Engineering News, Aug. 22, 1907), but in this case the free end of the easer rail is held against the track rail by a shoe casting which also gives it a bottom support. The same principle is embodied also in the Barschall rail joint which has been tried experimentally in this country and abroad.

FIG. 2. TRACK SCALE CONNECTION WITH RELIEVING RAIL IN PLACE.

AN EXAMINATION IN AERODYNAMICS recently set by Mr. Blin Desbleds at the Polytechnic School of Engineering is given below:

(1) Find the relation that must exist between the "resistance to penetration" of an aeroplane and its "resistance for sustentation" so that the aeroplane may move with the minimum propeller thrust.

(2) At what speed should an aeroplane with a given supply of fuel be flown: (A) in a duration competition; (B) in a distance competition. Assume in both cases the air to be still.

(3) Prove that the "speed of minimum power" of an aeroplane is that speed at which the resistance necessary for sustentation is three times the resistance to penetration.

(4) Explain what Col. Renard meant by the "quality" of a propeller. Prove that all similar screw propellers have the same "quality."

(5) What different quantities must be measured in the experimental study of aerial propellers?

(6) Show in what manner the efficiency of a propeller affects the maximum weight that can be lifted by an aeroplane.

(7) Define the term "propeller speed." Prove that the maximum effective work is done by a motor when the speed of translation of an aeroplane which it drives through the air is about 0.57 times the "propeller speed."

(8) Explain why it is advantageous to give to an aerial screw propeller as large a diameter as possible.

(9) What assumptions were made by Rankine in calculating the pressure which a fluid in motion exerts on a plane surface? Are those assumptions correct in the case of air? Give reasons.—From "The Engineer," London, June 9, 1911.

A Cross-Beam Concrete Floor System.*

By ARTHUR PEABODY.†

One of the chief expenses in reinforced-concrete work is the false framing upon which the concrete is poured. About 50% of the lumber used in making falsework is usually destroyed on taking down. Any system by which the major part of this can be saved results naturally in a decrease in the total cost of the building. In applying concrete construction to small work the scale of parts involves expensive and intricate preparation of false work so that the cost of this part sometimes exceeds the value of the concrete poured upon it.

There is room for trouble in constructions where a certain beam supports a considerable area. Such a beam is usually calculated to do the work intended, with a good margin of safety, but suppose the casting of the beam proves to be faulty, or in some manner the beam suffers slight damage. At once the entire area is threatened. This suggests the arrangement of many beams of small size, each supporting a small floor space. To this there arises the objection of increased cost. Beams of long span and narrow width suggest cross bracing, and again the comparison with wood construction suffers as regards expense. The good elements of wood construction are however precisely those of advantage in concrete. Wood beams are of long span, slight dimensions, and are set closely together. Each beam is braced to its neighbor by cross bridging. Under the beams all sorts of pipings are extended, and a flat ceiling is placed beneath. Upon the beams the floor is laid. What could be more reasonable and convenient? Should a pipe fail it requires only the removal of the ceiling for its repair. Should it be necessary to change the dimensions of rooms the necessary readjustments are readily made. Should a beam be slightly defective, or suffer injury, the beams adjacent will support the load, or if necessary, a section can be replaced without removing a large area of the floor. None of these advantages are to be had in the "mill type" of floor construction.

A system employed at the University of Wisconsin has been found practical, economical and effective, and for buildings intended for ordinary use more satisfactory than the "mill type" of construction. In competition it has been found less expensive where the requirements of the specification for the steel and other elements forming a necessary part of good construction have been conserved. This has been put to proof by obtaining alternate propositions on the same work, imposing only the requirement that the steel shall be strained not to exceed a certain amount, that spaces shall be provided for pipes, etc., and that the ceilings shall be flat.

Other systems approach the practical values of this one in some degree, as for instance that one where hollow tiles are used in place of the wood cells. Where but one building is to be constructed the cost of the cells might excel the cost of the tile. Where the building is of several stories, or in buildings of large enough area so that one part can be constructed before another, thus permitting the repeated use of a reasonable number of cells, the cost of the tile would probably exceed the proportionate cost of wood cells. The tiles serve no useful purpose except as forms between which the beams are cast, and their weight adds to the dead load of the floor construction. In either case a floor sheet must be placed on top, and the ceiling must be furred to receive piping and other accessories. Of course, such pipes may be buried in the floor sheet, but there is serious objection to this. It is done in most fireproof buildings, but the expense of repairing damage in case of leakage of water, gas or electrical current is made very heavy on account of it. Changes also are very expensive and difficult, and it is safe to say that every building will be changed over a number of times before it becomes obsolete.

The system or design of the floor construction in use at the University of Wisconsin consists of an arrangement of narrow beams spaced at about 3 ft. centers and braced by cross-beams at 6½ ft. centers. The beams are formed by employing a series of wooden boxes, with slightly flaring sides and ends, laid face down upon a system of supporting planks upheld by shores. The intervals between the boxes or cells being filled with concrete constitute the beams and cross-braces of the floor. The concrete is reinforced with steel after calculations made by the Dean of the Engineering Department of the University.

Upon the beams a floor sheet is poured, reinforced with steel wire fabric and finished with a wearing surface of cement and granite "fine stuff."

The reinforcing steel consists of round rods enclosed in loose stirrups. In the girders the rods are bent according to the best practice. Straight rods are used in the joists with counter flexure rods over the girders. In the cross braces small single rods are placed. The stirrups are of the U form, but to secure correct spacing and holding, several stirrups are bent from a single rod forming a unit series. These have been found very convenient on account of stability and resistance to drifting, falling and other annoying peculiarities of single stirrups. Mild steel has been employed in all work. High tensions have been prohibited, as well as calculated tension in concrete. This may be conservatism, but is no doubt wise. The effort of the architect has been to simplify and reduce the cost of work and to retain the good elements of old-fashioned constructive systems; to provide reasonable means of access to parts for repair and changes and to bring back the forms of surfaces on the interior of buildings which long custom has found most suitable and agreeable.

The rough way in which concrete is now mixed and cast, the danger of imperfect castings and the liability of damage to concrete in stripping forbid the use of very slender parts at present. For private house work the concrete floors of to-day are probably excessive in strength. Refinement in the falsework and casting will come in time, however, and it is to be expected that future constructions will be very much lighter and less expensive.

By the system described, spans from 12 to 26 ft. have been successfully cast at the University during the past two years. It is proposed to cast beams of 28-ft. span this year. These will require joists 8 ins. wide on the bottom, 14 ins. deep and 10 ins. wide on top. With a spacing of 3 or 4 ins. from center to center of joists the amount of concrete employed does not seem excessive. The cross braces in the floor, due to the intervals between the lengths of cells, have not been considered in the estimated strength of the floor. Their value in holding the joists, against lateral strain is unquestionable and they serve also to distribute the load upon the floor. The increased width of the beams at the top, due to the flaring sides of the molds gives increased resistance to crushing, while the narrower bottom, enclosing the steel, is sufficient and economical.

The calculated strength of the floor is entirely in the beams. That is to say, the floor sheet is not expected to increase the compressive strength of the joists as in the T-beam. The floor, reinforced with a woven wire fabric simply applies the load to the beams.

In casting this work the supporting columns are poured first and are left over night to shrink. The girders and beams follow, being also allowed to shrink, after which the floor sheet, almost a separate item, is cast and finished with cement and granite.

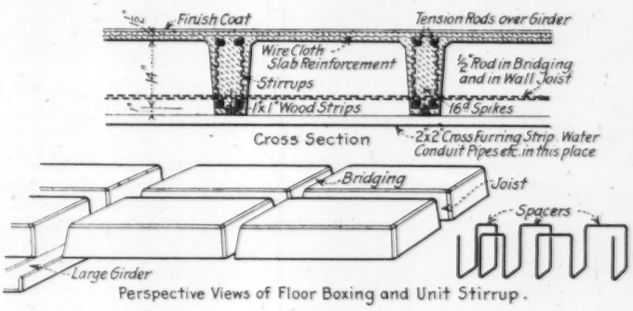
This method of working has been followed upon finding that heavy members need time in order to avoid cracking at the junction with the thin floor sheet. It has been found that the floor sheet may be cast at any convenient time, care being taken to clean the upper surfaces of the beams to secure good contact with the floor. In fact with a sufficient number of boxes or cells an entire building may be constructed, casting the posts, girders and joists, but leaving the floor sheet to be placed after the building has been enclosed. For attaching the ordinary ceilings to this construction small strips of wood are cast into the bottom of each joist and secured by bent nails, thus affording a ready means of applying the furring strips for the ceiling. These in turn give the needed spaces for pipes, etc. Upon the furring strips wire lath or plaster board is nailed and the plastering is applied.

The falsework for columns and girders is composed of dressed planks put together in the ordinary way. These parts suffer the least injury in removal and may be set up a good number of times. The cells rest upon the girder boxing where adjacent, forming the falsework for the upper part of the girders. In other locations they are supported by the plank scaffolds above described or upon the inside edge of the walls. In all places they are carefully leveled so that the concrete cannot penetrate between the scaffold planks and the cells. A few nails from below hold the cells securely to the plank.

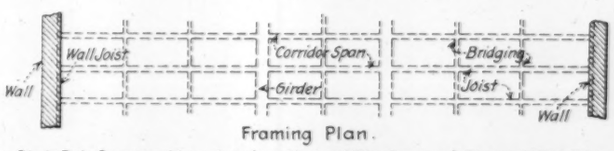
The spaces between ends of cells may vary somewhat, where convenient. Nice adjustments do not give great results where labor is expensive. Making the joists narrower on one side of a girder than on the other, on account of a slightly shorter span does not bring final economy at times. It is simpler to make the "lay out" regular and strong enough for the longer span.

With the completion of the falsework the floor is ready for placing steel and casting concrete. The supporting columns are poured first and while the concrete is settling the steel is placed in the girder and joist channels. The "unit stirrups" are set in the ends of the girders and joists, being held up from the bottom of the forms by the small wooden strips to which the ceiling furrings are to be nailed later. The stirrups confine the tension rods of the beams. The steel is laid in the girders and joists of the entire floor before any part is covered with concrete. It may be inspected all together, corrections made, and the pouring is then begun. As fast as the joists are filled with concrete the counter flexure rods of the joists are floated in the concrete, extending over the girders and the work is ready for the floor sheet. At the end of the day's work the concrete of the joists and girders is dammed off at the center of the spans and the work is resumed the next day.

The second day's work usually begins with pouring the floor sheet on the area completed the day before. The woven steel fabric is unrolled over the surface and the concrete poured upon it. When sufficiently hard the surface finish is applied and the floor is completed. The pouring of the remaining joists follows the part of the sheet, using a half day on the sheet and the other half day on the joists and girders so that no part of the unfinished floor is more than one day old.



Perspective Views of Floor Boxing and Unit Stirrup.



Framing Plan.

Slab Reinforcement:— *American Steel and Wire Company's Diagonal Mesh Wire Cloth. Style No. 26 or Expanded Metal; No. 9 Metal, 6" Mesh; or No. 10 Metal 4" Mesh (Birmingham Gage).*

Eng. News

DETAILS OF CROSS-BEAM CONCRETE FLOOR SYSTEM.

TABLE OF SIZES FOR LIVE LOAD OF 60 LBS. PER. SQ. FT.

Span in feet.	Width of joists at bottom, in ins.	Reg. steel, area in square ins.	Number and size of rods.	Number and size of stirrup.
14	4.0	.375	2—½"	4—¼" at each end.
16	4.0	.490	2—⅝"	4—¼" " " "
18	4.0	.620	2—¾"	4—¼" " " "
20	4.5	.760	2—¾"	6—¼" " " "
22	5.0	.920	2—¾"	6—¼" " " "
24	6.0	1.100	2—⅞"	8—¼" " " "
26	7.0	1.280	2—1"	8—¼" " " "
28	8.0	1.500	2—1"	8—¼" " " "

Practice has shown that the floor sheet is not separable from the joists even when poured after the joists have been set for several days. The finishing of the surface of the floor must be done of course soon after the sheet is poured. The entire work is allowed to set for three or four days before the mason work of the walls is allowed to proceed, but no stripping is done until after 14 days. The girders and posts are then stripped and the cells are drawn out from underneath. For this work a chain about the interior framing of the cell is looped over a stout lever and one end of the box is started, whereupon it falls out, ready to be used over again. Small shores are then placed under the joists and left for a short time.

The cells first made at the University were built of pine sheathed with yellow pine flooring quite smooth and carefully put together. These cells were successfully drawn and were used 15 times without a great percentage of loss. Their cost was approximately $2.50 each. Each cell presented 28 sq. ft. of surface, making a first cost of 8.9 cts. per sq. ft. After 15 casts the cost per sq. ft. remained at about 0.6 cts. per sq. ft., assuming that the cells were then worthless. The contractor then covered them with sheet iron, at a cost of $1.40 each and expects to use them probably 15 times more. This iron covering is well greased before using.

At this time a good number of new cells were constructed, also covered with iron. These were well built but without the same care in smoothing the surface on account of the iron covering. These cells slip out of the

*Extracts from an article entitled "Field Work in Concrete Construction at the University of Wisconsin, in "The Wisconsin Engineer," May, 1911.

†Supervising Architect, University of Wisconsin, Madison, Wis.

concrete so easily as to show a great advantage in the use of a metal covering which presents a smooth unbroken surface to the concrete. It obviates also the swelling of the wood covering from dampness, which made the drawing of the first cells rather hard at times and destructive to the cell. The life of a cell depends of course on the treatment it receives. Some were wrecked the first time they were used. Many of them were in apparent good order except as to the lower edges after 15 casts. Their weight occasioned some damage, especially if allowed to fall to the ground on being drawn. The most convenient size of cells appears to be 2 ft. 8 ins. wide × 6 ft. 6 ins. long. Beyond this size they cannot be so easily handled. Some cells were made 7 ft. long and a few 5 ft. At times it is necessary to build special cells to finish out a span.

Variation in strength of floors was made in spacing the cells farther apart, making the concrete joists wider for the heavier floor. The percentage of steel was then increased according to rule. The joists were sometimes left exposed, over laboratories, and made a very presentable appearance. This gave opportunity for the convenient support of shafts, etc. Electric conduits were there left exposed, following the direction of the joists and cross bridgings. In other buildings plastered ceilings were attached in the ordinary manner. Steam coils were suspended from hangers secured by drilling the joists at the neutral axis. For line shafts, bolts were cast in the concrete at regular intervals, to which timbers carrying the shaft hangers were bolted.

The floor sheet, 2½ ins. thick including the sand finish, seems fragile. Experience, however, shows that except for the mechanical difficulty of casting, the floor could be thinner. Floors have been broken during construction, but by blows which would break other floors considered amply strong. On one instance a scaffold plank fell about 16 ft., striking on end. At another time a piece of sand stone 3 ft. long, weighing about 450 lbs., fell the same distance upon the floor. Each of these accidents made a break about a foot square, leaving the steel fabric but little damaged, and the repair of the floor very easy. Drilling through the floor for extending steam risers or setting anchor bolts shows the strength to be ample if not excessive.

All floors thus far constructed have been covered with a finishing coat of cement and granite, following the usual method in sidewalk work.

An example of the use of the system, with resulting costs is shown in a floor constructed in the Mining Laboratory of the University of Wisconsin. The floor area was approximately 4,500 sq. ft. The superimposed load was taken at 200 lbs. per sq. ft. This work being done by the University forces gave an opportunity to know exact costs, as follows:

		Per sq. ft.
Crushed limestone, sand and Portland cement	$474	or 10.54 cts.
Lumber for girder and post forms, etc.	252	or 6.60 cts.
Cost of placing falsework and cells..	250	or 5.55 cts.
Cost of steel reinforcement.....	354	or 7.86 cts.
Labor of placing steel and pouring cement	200	or 4.44 cts.
Labor of removing falsework.....	50	or 1.11 cts.
Use of 200 cells at 1/15 original cost.	33	or .73 cts.
Total cost	$1,613	or 35.83 cts.

The cost of lumber for girder and post forms is of course too high, no allowance being made for the value of the material after removal. This lumber was not greatly damaged, but the exact value is hard to set down, as no subsequent floors of good area have been constructed by the University where it could be used. If the material could be taken to be as durable as the cells the proportionate lumber cost would be brought down to $16.70 instead of $252 and the total cost to $1,387.70 or 30.84 cts. per sq. ft.

In applying this system it is to be noted that except in the items of concrete and steel a light floor will cost as much as a heavy one. It can be cast with the same cells, planks, shores, etc., and with approximately the same amount of labor. The increase on the heavy floor would of course be in the labor of pouring the larger amount of concrete. In the use of this laboratory the floor calculated to carry 200 lbs. per sq. ft. has been greatly overloaded, with no bad results, however, which indicates that the actual strength of concrete construction is probably far in excess of that calculated.

This suggests lower factors of safety or diminished sections, but chiefly, in building work, longer spans. The economies in materials are not great, as between a strong and a weak floor. The elimination of posts is of much greater interest. If spans up to 40 ft. could be safely employed the interiors of many buildings might be quite clear and the parts arranged in the most convenient way, unhampered by lines of supporting columns. With the present depth of 14 ins. for the cells there is of course an economical limit to spans. Deeper cells would bring a new set of calculated values, however, so that there may be no reason why long spans should not be made use of.

A Gas-Engine Pumping Plant.*

The water supply of the town of Haddonfield, N. J., previous to 1905 had been a source of frequent complaint on account of poor quality and lack of pressure and quantity for adequate fire service. In 1909, after prolonged investigations, negotiations and legal proceedings, an order was given for a new plant, which was completed in 1910.

The new water-works derives its supply from four artesian wells driven some 220 ft. to a water-bearing strata of pure white sand and gravel overlaid by an impervious stratum of clay, which excludes surface water. From each well a 6-in. pipe leads to a 12-in. main running to a watertight concrete cistern 30 ft. in diameter and 42 ft. deep. The 12-in. main dips 30 ft. down into the cistern and as soon as the water is pumped below the level of the main a supply is siphoned from the wells.

In Fig. 1 is seen the exterior of the new pumping plant, located at the foot of a hill and at the edge of the basin in which the artesian wells were driven. To the right of the building is seen the coal bin with a bridge to the station, while to the left is seen the covered pumping

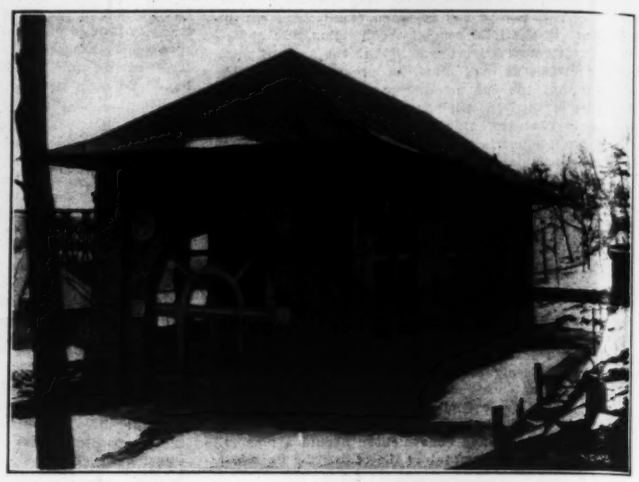


FIG. 1. HADDONFIELD GAS-ENGINE PUMPING PLANT.

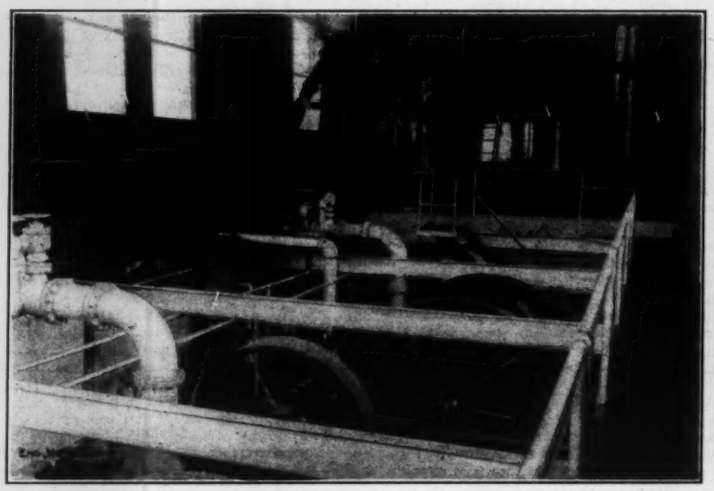
cistern. The building and equipment have been kept as nearly fireproof as possible by the elimination of wood in construction.

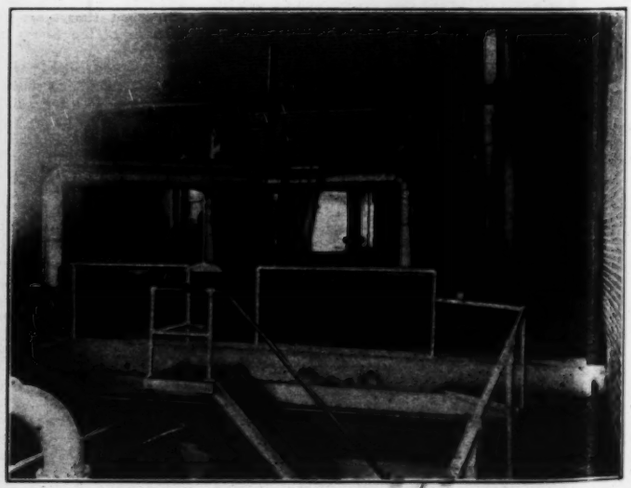
Fig. 2 is a general view of the interior of the station. There are two complete duplicate pumping units each consisting of a gas producer, gas engine and triplex geared pump. Either operating unit can be run independently of the other or both may be used at the same time, and each has more than twice the present required capacity under ordinary conditions. The units are cross connected also so that one engine may run on the producer of the other unit.

From Fig. 2 it is seen that the producers are on a platform at ground level while the pumping machinery is in a pit 8 ft. below. An iron walk encircles the machinery pit and connects the front entrance with the producer platform. The floor of the machinery pit is 5 ft. below the level of ground water, so that it is subjected to an upward pressure of some 300 lbs. per sq. ft. The floor is of impervious concrete, several feet in thickness. The floor was located at this low level to prevent excessive suction head when the water level in the cistern was drawn down by heavy pumping.

The producer platform measures 16 × 24 ft. The producers are of a suction type burning anthracite fuel. Each consists of the producer proper with a superimposed cast-iron evaporator. In Fig. 3 may be seen the elevated charging

*Arranged from information furnished by the W. R. McLain Co., Philadelphia, Pa., for the Otto Gas Engine Works. The data is derived chiefly from a report by Mr. Geo. Pfeiffer, Jr., of Camden, N. J.





FIGS. 2 AND 3. INTERIOR OF THE HADDONFIELD PUMPING STATION.

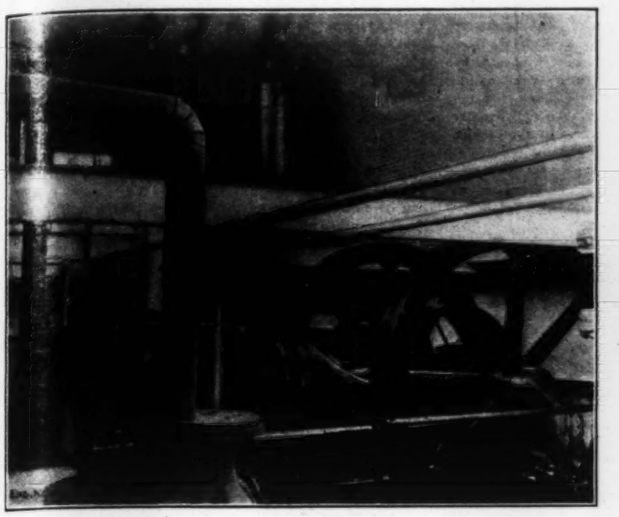


Fig. 4. Engine Side.

Fig. 5. Pump Side.

FIGS. 4 AND 5. 85-HP. GAS-ENGINE, PUMPING UNIT, HADDONFIELD STATION.

platform for the producers, reached from the producer floor by an iron stairway. The platform is of steel and large enough to give access around the tops of both producers for stoking and cooling. The charging platform extends to a door in the side of the building and runs beyond as the bridge shown in Fig. 1, leading to the coal bin 20 ft. away and on the same level, as shown in Fig. 6. At the top of the embankment, adjacent to the west side of the plant and 43 ft. above the level of the producer room, is a railroad siding with a concrete and steel coal trestle. A chute extends from beneath the trestle to the bin which is built into the embankment. This bin has a capacity of 50 tons and is built with a concrete floor and back wall, but with timber front and sides. The coal is wheeled in a barrow from this bin directly to the charging openings in the producers.

Each engine is an 85-HP., horizontal, single-cylinder, Otto type directly connected to the pump, through a friction clutch. Fig. 4 shows the engine side of the unit and Fig. 5 the pump side. As shown in Fig. 5, the friction clutch is operated by a hand wheel. Each pump has a capacity of 1,250,000 gals. in 24 hours, pumping against a total head of 250 ft. This requires 55 HP., which is only 65% of the rated capacity of the engines, leaving at least 35% overload capacity so that the supply may be furnished at a temporarily-increased pressure of 150 lbs. in case of fire.

There is an auxiliary equipment of one 2-HP., vertical, gasoline engine for driving a compressor, centrifugal blower and drainage pump for the machinery pit. The compressor, with a storage tank, is used for starting the larger engines. The blower is used for starting the producer fires in the morning or after a long shut-down.

The piping is all exposed and accessible. The suction lines are laid beneath the floor and concrete channels and are covered by steel floor plates.

To remove from the room any dust arising during the necessary stoking of the producers, a line of galvanized pipe, shown in Fig. 3, runs from a suction fan to the fire doors of each producer. Whenever clinkers are drawn out, at intervals of several hours, the fan is started and discharges the dust outside the building.

From the pumping station the water is forced through a 12-in. discharge line 2,000 ft. to a stand-pipe, located on one of the highest elevations in the town. There is a total length of 66,000 ft. of cast-iron pipe in the distribution system.

The cost of pumping is claimed to be $11.20 per 1,000,000 gals., compared with an estimated figure of $18.10 for a steam-driven plant. In these figures comparative data of steam pumping plants of similar size elsewhere have been used, except where actual prices bid for a steam plant here were used in determining charges for interest, depreciation, etc. These figures for pumping do not represent cost of service outside the building and contain no charge for interest, depreciation and sinking fund on the system beyond the station.

Changes in Methods of Excavation at the Lower Miraflores Lock Pit, Panama Canal.*

Some important changes have been made in the method of excavating hydraulically in the lower lockpit at Miraflores, and in the Canal prism south of that point. Heretofore, the plan has been to dislodge the material in the sides and at the bottom of the excavation by monitors, which sluiced it to where the dredge pumps mounted on concrete barges, could lift it into the fill of the west dam, or elsewhere, as desired. This plan provided for settling the concrete barges into sumps, and it is owing principally to the difficulty experienced in getting the barges in a suitable working position that it has been decided to abandon them. Stumps and the trunks of old trees that had become buried in the soil covering the site of the hydraulic operations in the lower lock at some previous period were among the obstacles encountered in settling the barges effectively.

Under the new arrangement, sumps will be created to various depths in the area to be excavated, and the pumps removed to positions alongside. This will do away with any need for the three concrete barges built expressly for mounting the dredge pumps and motor equipment, and one of them has already been dynamited and removed. It is proposed to break up a second one due to the difficulty of getting it out of its present position, but the third may be removed and used elsewhere.

The depth has reached a stage that permits a change in the method of working the hydraulic monitors, or giants. Instead of directing the play of the water against the surface of the material, the process of undercutting, which will allow the over head mass to fall in as the work proceeds, will, in future, be employed. Dredge pump No. 2 has been shipped to Gorgona shops for repairs, and it is proposed to install temporarily in its place the relay pump originally purchased for relaying the material into the fill of the dam. The relay pump will be located directly in front of Cocoli Hill. The face of this hill contains a great many small boulders which the relay pump is particularly well adapted to handle, inasmuch as its impeller admits pieces of rock 8 ins. in size, compared with 6 in. pieces, the maximum size handled by the other pumps. It is estimated that the greater proportion of the boulder material found in this locality can be sluiced and pumped out in this manner. The sump where the relay is to be situated will be the main one; it will be sunk to 55 ft. below sea level, and the dredge pump will occupy a position on a bench alongside about 25 ft. below sea level.

*From the "Canal Record," June 21, 1911.

FIG. 6. COAL TRESTLE, CHUTE AND BIN; HADDONFIELD PUMPING PLANT.

COMPULSORY ELECTRIFICATION of the railways entering Boston is postponed for a year at least. The Massachusetts Senate on June 27 by a vote of 19 to 13 voted to refer to the next legislature the pending bill requiring the railway companies to submit plans for electrification by Sept. 1, 1912.

THE RENEWAL OF WRECKED BRIDGES on the Southern Pacific Ry. lines in Mexico (that is, the bridges destroyed during the recent political troubles), is now in progress. The steel bridges were seldom injured, the destruction of railway property being mainly in the way of burned pile trestles, stations, etc. In almost every case where trestles were burned, the trestles were across waterways which only carry water during the rainy season. As the beds of the streams were dry, they were readily cribbed with track ties, this requiring no skilled labor other than intelligent supervision. After traffic was re-established, the combined construction and maintenance forces began the rebuilding of the structures. This work will be completed before the rainy season sets in. There was no organization of a special character required, other than to get together sufficient force to complete the work quickly, and as Mexican carpenters are plentiful and skilled in their trade, this was easily accomplished. The work is under the direction of Mr. L. H. Long, Chief Engineer of the Southern Pacific Ry. Co. of Mexico.

Improved Air-Brake Equipment for Controlling Modern Passenger Trains.*

By WALTER V. TURNER.†

With the introduction of heavy passenger cars (125,000 to 150,000 lbs.), the brake force required to control such heavy cars with approximately the same effectiveness as is obtainable with the apparatus used on lighter cars became so great as to exceed the capacity of a single brake cylinder, even with the highest brake cylinder pressure and greatest multiplication of its power by leverage that could be permitted. The increased speed and weights of trains and the economy of time necessary for the highest operative efficiency under modern severe traffic, together with the increase in length of trains and the much greater volume of air which must be handled through the brake pipe, have imposed conditions which the type of brake adequate for past conditions has been unable to meet satisfactorily.

While a high maximum emergency stopping power is required to insure the safety of passengers and rolling stock, the ordinary service functions and automatic safety and protective features became hardly secondary in importance. The necessity for a different treatment than that heretofore practiced in the application of braking or retarding forces on modern heavy passengers is outlined as follows:‡

1. Increased unbraked locomotive weight.
2. Increased train momentum.
3. Increased brake rigging deflection and false motion, due to severe stresses in car members and other causes, which greatly increase the piston travel.
4. Increased brake leverage ratio, with consequent increased piston travel and lower maximum cylinder pressure.
5. Increased time to obtain brake effectiveness, on account of large cylinder volumes.
6. Decreased brakeshoe coefficient of friction due to greater brakeshoe pressure and speeds.
7. Possible breaking down of the brakeshoe under the severe conditions imposed.
8. Capacity of single cylinder type of brake equipment exceeded.
9. Excessive amount of air used when releasing and recharging.

Some of the operating conditions involved in the committee's considerations which are not directly mentioned in the report are greater frequency in trains, increased number of parallel tracks and higher speeds with the same distances between signals as formerly. These introduce problems which are primarily for the operating department to solve but must be given no less consideration by the mechanical department.

As a result of a thorough consideration of these conditions by the representatives of various railways and others interested, whose conclusions were confirmed and recommendations tested by one of the most significant series of brake tests ever held (namely, Lake Shore emergency brake tests of 1909), certain requirements were established as essential in modern high speed, heavy passenger train service. On this basis the "PC" passenger brake equipment was developed to meet the requirements referred to, by combining the ordinary functions of the quick action triple valve with such other operative features as were found necessary.

Two brake cylinders per car are used. Only one brake cylinder operates during service applications, but both are brought into play when an emergency application is made. This gives the necessary increased braking power for emergency applications, not by an increased pressure in one brake cylinder (as in previous equipments), but by bringing the same brake cylinder pressure to act upon the pistons of two brake cylinders instead of one. This means that double the maximum service braking power is obtained in emergency applications. A slack adjuster is used on each brake cylinder connected by a pipe to the proper slack adjuster hole in the service brake cylinder. In this way both slack adjusters are made to operate simultaneously and the slack is taken up equally for both cylinders, depending on the travel of the service brake cylinder piston. Two supply or storage reservoirs are used, denoted as the service and emergency reservoirs, respectively, according to the brake cylinders to which they are related.

Some of the novel functions of this "PC" equipment are as follows:

A. Graduated release and quick recharge, obtained as with previous improved types of triple valves. The air supply to assist in recharging and to accomplish the graduation of the release is taken from the emergency reservoir.

B. Quick rise in brake cylinder pressure, provided for by insuring a prompt movement of the parts and direct and unrestricted passages from reservoirs to brake cylinders during applications.

C. Uniformity and maintenance of service brake cylinder pressure during the stop, provided for in the same manner as by the application portion of the distributing valve.

D. Predetermined limiting of service braking power, fixed by the equalization of the pressure and application chambers of the control valve. This eliminates the safety valve feature of previous equipments and is both positive and uniform.

The maximum service brake cylinder pressure (service equalization) is fixed at 86 lbs. instead of at 50 lbs., as with previous equipments. On this account it is possible to use a much lower total leverage ratio (which is necessary if the required efficiency of the foundation brake rigging for the classes of cars considered is to be maintained). This equalization pressure corresponds to a reduction of 24 lbs. from 110 lbs. brake pipe pressure, which is the reduction required with the old style high-speed brake equipment to give maximum service brake cylinder pressure (60 lbs., corresponding to the opening point of the high speed reducing valve). This insures uniformity of service operation of old and new equipments mixed in the same train.

E. Automatic emergency application on depletion of brake pipe pressure. If the brake pipe reduction is still further continued below the point at which the pressure and reduction limiting chambers equalize, the parts move to emergency position and cause both the quick-action and emergency portions to operate, starting serial quick action throughout the train and obtaining emergency brake cylinder pressure.

F. Full emergency braking power at any time. As the operation of the emergency and quick-action portions just described is dependent only upon the movement of the parts to emergency position and as this can be caused at any time by making an emergency application with the brake valve, conductor's valve, etc., it follows that full emergency braking power can be obtained at any time, irrespective of a service application previously made.

G. The service and emergency features being separated permits the necessary flexibility for service applications to be obtained without impairing in the slightest the emergency features of the equipment.

H. A low total leverage ratio, with correspondingly greater over-all efficiency, is made possible by the use of two brake cylinders per car, and also higher service equalization pressure.

J. Less sensitiveness to the inevitable fluctuations in brake pipe pressure, which tend to cause undesired light applications of the brake. This insures against brakes creeping on or dragging, burning of brake shoes, delays to the train, and so on.

K. Maximum rate of rise of brake pipe pressure possible with given length of brake pipe with consequently greater certainty of brakes releasing when a release is made. With non-graduated release equipments or previous graduated release equipments operating with graduated release feature cut-out, the recharging of the brake pipe toward the rear end of a train of any length may become very slow, due to the draining away of the air from the forward end of the brake pipe by the large reservoirs with large size feed grooves which take their entire supply from the brake pipe only.

The quick recharge feature of the "PC" equipment overcomes this difficulty, with graduated release cut in, by restoring the pressure to the pressure chamber on each car at as rapid a rate as the brake pipe pressure alone can be raised by the flow of air through the brake valve. Consequently up to the point of equalization of the pressure chamber and the emergency reservoir under each car (about 5 lbs. less than normal brake pipe pressure) no air is being drawn from the brake pipe. This insures a prompt and certain release of the brakes, and a rapid recharge and prompt response to successive reductions which may be made, because (1) practically no air is drawn from the brake pipe, (2) pressure chamber and brake pipe recharge at the same rate, and (3) with graduated release cut-out no air is supplied to pressure chamber except from brake pipe.

In this way a safety feature is provided that warrants its adoption when conditions permit, that is, when the majority of cars in the train are so equipped; and an advantage is obtained that is essential, if the release of the brakes is to be prompt and assured.

First, as to the safety feature. At present two application stops are effected and this means that after the release of the first application the engineman must immediately come to lap position with his brake valve. If the second application is not required, as when a signal goes to clear, the brake valve handle may be left in this position, thus permitting the brake system to deplete, since all brakes have released. With a graduated release the two-application method is not required, as the same result can be more safely, certainly and quickly obtained by graduating the release, which is done by the same movement as described before; that is, going to release and coming back to lap, but in this latter case if the handle is not moved back to its proper running position the brakes on the cars remain applied and consequently no danger of the system becoming depleted is probable, as the handle must be moved to its proper position before speed can be obtained.

With regard to the second advantageous feature of a graduated release equipment, or its equivalent (by equivalent is meant any equipment which carries a large reserve supply of air under the car for emergency purposes and for recharging the auxiliary reservoir), a prompt and certain release of the brake is assured. Because of the weight of a modern car and the great force required to stop it in a reasonable time and distance, large volumes of air must be carried even for service braking. This means that the brake pipe pressure cannot be increased at anywhere near the same rate as when the trains were shorter and the volume much less.

Since it is not, in the last analysis, an increase in pressure, it is absolutely essential that the rate of increase be such as will produce this difference of pressure, and it is obvious that this can be done with much greater certainty if only the brake pipe is to be increased and not the brake pipe and auxiliary reservoirs. That is, if the brake pipe pressure is to be raised quickly, insuring the release of the brakes, it must not be necessary to raise more than the brake pipe volume.

With the "PC" equipment, when the graduated release feature is operating, this is all that is required, while when the graduated release feature is cut out, only the pressure chamber, which is of comparatively small volume, is added to the brake pipe, and this great improvement is quite essential if freedom from stuck brakes is to be realized.

While a quick recharge of the storage reservoirs of the equipment is insured, as explained above, thus guarding against depletion of the system when reapplications of the brake are required in rapid succession, the use of a high (86-lb.) service equalization pressure still further protects against insufficient braking power,

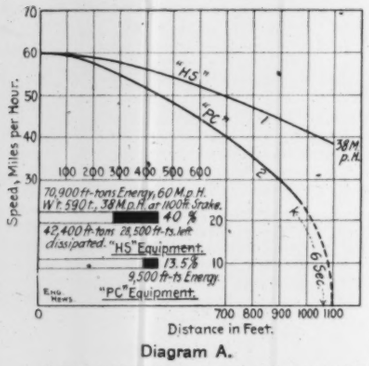


Diagram A.

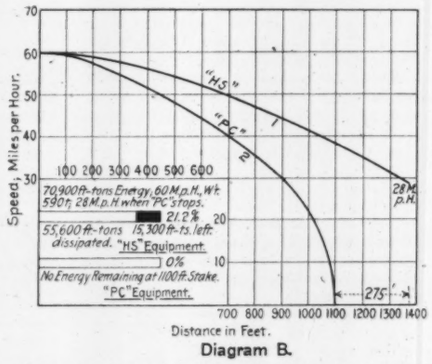


Diagram B.

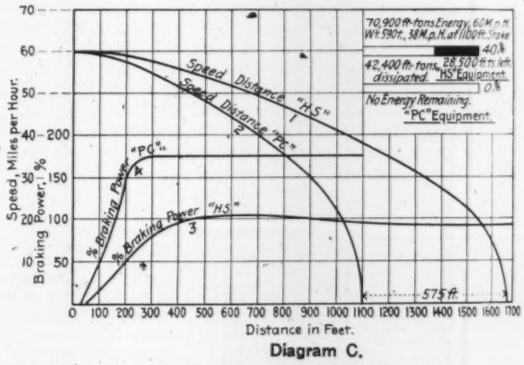

Speed, Miles per Hour.
Braking Power, %
Speed Distance "HS"
Speed Distance "PC"
% Braking Power "PC"
% Braking Power "HS"
70,900 ft-tons Energy, 60 M.p.H. Wt. 590 t., 38 M.p.H. at 1100 ft. Stake
40 %
42,400 ft-tons, 28,500 ft-ts left dissipated. "HS" Equipment.
0 %
No Energy Remaining. "PC" Equipment.
575 ft.
Distance in Feet.

Diagram C.

DIAGRAMS SHOWING COMPARATIVE RESULTS OF "HIGH-SPEED" AND "P. C." BRAKE EQUIPMENT IN STOPPING PASSENGER TRAINS.

*Abstract of a paper read at the annual meeting of the Air Brake Association, in Chicago, May 25, 26.

†Westinghouse Air Brake Co., Pittsburg, Pa.

‡Report of the Committee on Train Brake and Signal Equipment of the M. C. B. Association, 1910; in a paper before the New York Railway Club, April 16, 1909, entitled "Development in Air Brakes for Railroads"; a paper in the Franklin Institute "Journal" for December, 1910, and January, 1911, entitled "Air Brakes as Related to Progress in Locomotion," and in Appendix A of the third (1910) annual report of the Block Signal and Train Board of the Interstate Commerce Commission, entitled "Principles and Mechanical Development of Train Control Apparatus for Steam Railroad Service."

by making it impossible to release until approximately 90 lbs. brake pipe pressure is secured. The standard pressure carried in the brake pipe is 110 lbs., but with the high speed brake it is possible to release and start the train with not more than 60 lbs. or 65 lbs. pressure throughout the system. This affords but a meager reserve of power in case a quick stop suddenly becomes necessary about the time full speed is attained, and has led to it being generally insisted that at least 90 lbs. brake pipe pressure be indicated by the gage before the train is started.

The fact that the service equalization pressure, with the "PC" equipment, is 86 lbs., and that the brakes will not release until this brake pipe pressure is obtained, replaces this insistence by an assurance that the train is protected against being started before the necessary reserve power has been obtained. It will be observed that it is necessary to raise only the brake pipe to this pressure to insure a release and the requisite margin of safety, while the graduated release and quick recharge features of the equipment then recharge the reservoirs of the equipment as fast as the brake pipe is being recharged.

While, of course, 90 lbs. will not give as much braking power as 110 lbs., it affords a much greater margin of safety than if the train can be moved with only 60 lbs. pressure in the system, as is frequently the case when the high-speed equipment and small pump capacity are used. The fact that pump will replace the air lost by leakage or brake applications but slowly is another reason why it is not safe to start the train until adequate braking power is assured.

A prolific source of trouble in this direction comes from the practice of running double header trains. The pump on the leading engine may be capable of furnishing an air supply ample for the operation of such trains as the single locomotive can handle, but was never intended to satisfy the extra demands imposed by the double header train. If the pump capacity is not sufficient to meet these demands, or if means are not available for utilizing the pump supply on both locomotives it is plain that trouble from "stuck brakes," failure to release, etc., will result.

The only safe way to permit the main reservoir and pump on the second engine to be utilized in assisting the head engine in releasing and recharging is to provide a main reservoir pipe and connections by which the main reservoir on the first and second engines can be connected, thereby enabling the man on the head engine to utilize the air stored in the main reservoirs of both engines.

As an illustration of what has been accomplished by the improvements just outlined, the curves on charts A, B and C contrast the performances of the quick-action automatic brake with high-speed reducing valve and the passenger control equipments. The stops shown are from a speed of 60 m. p. h. with a representative train of one locomotive and six modern passenger cars, the total weight of the train being 590 tons.

Chart A represents the "PC" train stopped at the 1,100-ft. mark and the high-speed train passing it at a speed of 38 m. p. h. (63% of its initial speed) at which point 40% of its original energy still remains to be overcome before the train is stopped. It will be noted that the latter portion of the curve 2 is dotted to indicate that the train with the high-speed brake equipment reached the 1,100-ft. point six seconds before the train with the "PC" equipment came to rest at that point.

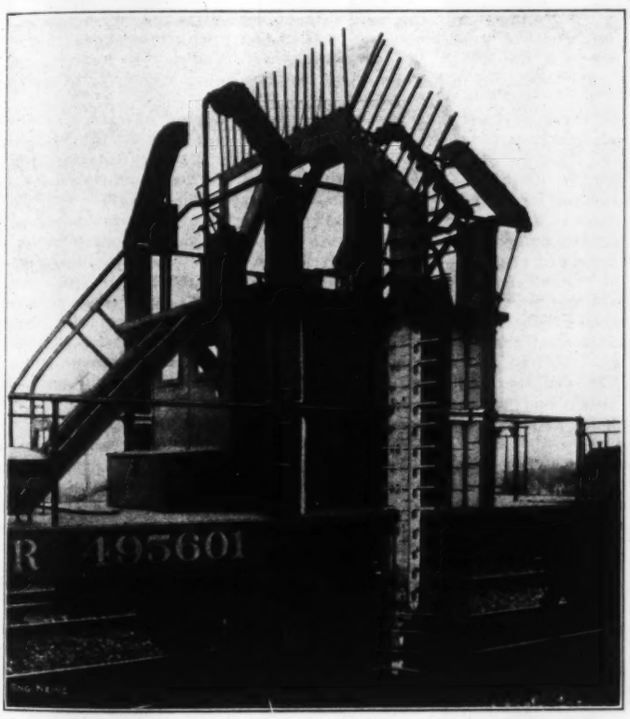
Chart B shows that the time the "PC" equipment train comes to a standstill the high-speed equipment train has run 275 ft. farther and is still running at the speed of 28 m. p. h., representing 22% of the original energy.

Curves 1 and 2 of Chart C illustrate the relative drop in speed as the trains approach the stopping point and show that the train with high-speed equipment ran 575 ft. further than that with the "PC" equipment. Curves 3 and 4 show the relative percentage of braking power developed on the two trains, and illustrate why the "PC" train stopped in the shorter distance and time.

The three cardinal advantages of the "PC" equipment are vividly illustrated by these curves: (1) the much higher percentage of emergency braking power; (2) the rapid rate at which maximum braking power is obtained; (3) the maintenance of maximum braking power throughout the length of the stop.

A New Clearance-Measuring Car of the Pennsylvania R. R.

The cut herewith shows the forward or gage portion of a new clearance car recently put into service on the Pennsylvania R. R.* The fixed clearance frame, mounted centrally over the truck, carries hinged fingers 2 ft. long at 6-in. spacing, which in any angular position show directly on a scale their net projection beyond the frame. A small loose board with feeler fingers 1-in. apart is also provided, for attachment anywhere along the frame, to measure the clearance outline at cornices of shelter sheds or other irregular objects close to the track. Forward of the main clearance frame is another frame having the same outline as the upper part of the main frame, but held on a vertical shaft sliding in a cylinder, and capable of being raised and lowered. The main frame measures the normal clearances, up to 17 ft. above top of rail, while the sliding frame is used for bridge clearances, etc., above 17 ft. and up to 20 ft.



GAGING APPARATUS OF NEW PENNSYLVANIA R. R. CLEARANCE CAR.

The main frame has a width of 10 ft. between elevations 2 ft. and 12 ft. above top of rail; its 4-ft. top bar is 15 ft. above rail, and the upper corners slope at an angle of 45°. The fingers have enough friction on their hinges to stay in any position to which they are deflected. Both main frame and sliding frame are illuminated by a belt of incandescent lamps set in housings with translucent glass front facing the frame.

The car itself is a steel flat-car 54 ft. 8¾ ins. long, or 30 ft. between truck centers. Its floor is 4 ft. 5¼ ins. above top of rail. At the clearance frames is an elevated platform 5 ft. 2¾ ins. above deck, for the use of the observers in reading the upper scales.

In the middle of the car is a small cabin, in the front of which, facing the clearance frames, are two large horizontal scales traversed by pointers. One of these indicates the curvature of track, and the other the superelevation; both are worked automatically, the curvature pointer from the track and the other from a long pendulum in the cabin. As the scales can be read from the observers' stand, the records can be taken simultaneously.

The car was designed in the office of the Engineer of Maintenance of Way, and was built at the railway's Altoona shops. It requires two men as a minimum, one to read the scales and the other to record; where clearances are close and irregular three men are required. We are informed that the car can be worked while running at 4 mi. per hr. (though this speed would doubtless affect the superelevation pendulum). Measurements can be taken day or night, and in dark tunnels, by virtue of the ample illumination of gages. The car is being run over the various divisions of the railway east of Pittsburg and Erie, to get a complete and correct record of clearances at stations, tunnels, bridges and other objects.

*A clearance-measuring car of the Baltimore & Ohio R. R. was described and illustrated in Eng. News, June 13, 1907.

An Ice Pyramid Built Up By an Artesian Well.

The unique ice structure shown by the accompanying illustration was built up designedly from the flow of an artesian well in South Dakota. The following description of the pyramid has been supplied to us by Mr. A. L. Van Ornum:

The pyramid of ice shown in the photograph was erected by the writer in the famous artesian basin of South Dakota, on the farm of Van Ornum Bros., Turton, Spink County. The foundation was started Nov. 5, [1910] by spraying just a sufficient amount of water to freeze as fast as it fell. The amount of water and position of the sprayer had to be continually altered with every change of wind and temperature.

An Ice Pyramid Built Up By An Artesian Well.
(Copyright, 1911, by A. L. Van Ornum.)

On clear days the white outline could be seen against the blue sky for many miles and its daily growth was watched by thousands of people who traveled on the nearby railroad. At night its magnificent beauty and splendor were even more striking, and in the clear, frosty moonlight it appeared like the ruins of an ancient cathedral.

After a warm wind had honeycombed it to the heart, the unique monument fell on the night of March 7. On the following morning nothing remained but the crumbled ruins of what had been the admiration of the whole community. Thus the mist that froze in splendor turned to vapor and passed away.

We are informed by Mr. W. H. Van Ornum that on June 4, 1911, ice from the base of the pyramid was still being used and that it was expected that there would be a plentiful supply through the summer. The ruins of the pyramid after it fell were covered with straw to delay melting.

We are indebted to Mr. Samuel H. Lea, State Engineer, Pierre, S. D., for bringing this ice pyramid to our attention.

Results of Some Experiments With Plastic Clays at the Bureau of Standards.

An interesting study of certain clays is reported by Mr. A. V. Bleininger in the "Bulletin of the Bureau of Standards," Vol. 7, No. 2 (May 15, 1911). While the work related directly to keramic questions, it has bearing also on the engineer's dealings with clay, and this includes a wide range of soils. The study gives some insight into the physical qualities of clays, and shows that the clay is permanently altered by preliminary heating to temperatures considerably below a baking temperature. This alteration is the greater in proportion to the temperature of preliminary heating, but begins even at moderate temperatures.

The work included a study of shrinkage, water content, plasticity (or rather viscosity), and granulometric composition, of a number of clays, most of which were characterized by excessive plasticity, while a few were more ordinary clays. No strength tests were made, so that the engineer, lacking this important factor for judgment, is not able to translate the results of the experiments directly into the terms most familiar to him. Also, the tests fail to give definite figures on the reduction of plasticity produced by the preliminary heating, and the degree of heating which would destroy the possibility of retempering and working is not indicated.

The object of the study was to learn whether certain clays of excessive plasticity can, by preliminary heating followed by retempering, be made to dry satisfactorily for keramic use (i. e., without destructive cracking and warping). The relation of clay experiments to the determination of standards (for which work the Bureau of Standards exist) is a little obscure. The results of the work are interesting, however, and a brief abstract here may be useful to our readers, especially because of the great length of the original (56 pages).

CLAY CHANGED BY DRYING.—Mr. Bleininger in his introductory remarks recalls that there are numerous evidences of a change in clay by drying. For example:

> In pottery work it has been found that the dried ware which is again returned to the plastic state does not possess the same working quality on the jigger that it possessed originally. Whether on sufficient working and aging the clays would resume their initial plasticity is an open question, though it would seem very likely that this would be the case as far as the usual dried clay is concerned.

While the shrinkage which takes place when a clay is dried at low temperature is usually balanced by a practically equal expansion on reabsorption of water, drying at higher temperatures seems to decrease both the amount of reabsorption and the volumetric expansion. It is not known whether mechanical working would restore the original qualities.

Further evidence of a change in the physical nature of the clay is found in the phenomena of water loss during drying. When a wet clay is dried by long-continued gentle heating, it shrinks during a certain time, after which the volume remains constant. However, loss of water continues after constancy of volume is attained, from which it may be concluded that the shrinkage is a settling of the grains into contact when the films of water between them are expelled (shrinkage water), while the further loss of water comes from the interstices (pore water). But, at any given temperature, after a time no further loss of weight occurs, whereupon heating to a higher temperature drives off more water, and so on. If this were due to any action unaccompanied by changes in the nature of the clay, the loss of water in successive equal temperature-intervals ought to be progressively decreasing. Careful experiments on a number of clays showed that such was not the case and that one 50° temperature interval would show a very much higher loss of water than the interval next below.

The further experiments with excessively plastic clays showed plainly that the clays become changed by heating up to 300° C., and gave some characteristics of the changes.

NATURE OF RAW PLASTIC CLAYS.—Fourteen clays were used, most of them being specimens of excessively plastic clays which could not be dried without cracking and destructive shrinkage. Their true specific gravities ranged from 2.451 to 2.784, and their shrinkages (in per cent. of volume of the dry test-piece) ranged from 16.9% to 48.2%, with one exceptional clay as high as 68.6%.

The amount of water required for working up the clays to their condition of best plasticity after drying at moderate temperature, varied from 42% to 67%; one fire-clay, a material of low plasticity, was exceptional in taking only 21% of water.

Mechanical analysis of each clay was carried out (after adding a deflocculating reagent such as caustic soda or sodium carbonate) by an apparatus comprising sieves up to 120-mesh followed by a three-compartment water-sorting device which separated out the finer grains down to an average size of 1/1500-in. The finest clay particles went out in the overflow, and in most of the clays this overflow matter was more than 50% of the total (minimum 40%, maximum 99%). Both in overflow percentage and in the granulometric composition of the residues in the sorting apparatus, the several clays differed widely. Generally, however, the differences of quality were better reflected in the percentage of overflow than in the residue percentages. The difficulty of drying was estimated to vary approximately as the product of overflow percentage and volumetric shrinkage (this latter based on "true volume of clay," however, instead of on volume of dried test-piece).

RELATIVE PLASTICITY; VISCOSITY.—To get a measure of plasticity, experiments were made to determine the viscosity of a thin suspension ("slip") of the clay, by means of a paddle stirring device.

It was found that while the clays obviously possessed greatly different plasticity, all the clays tested were practically equal in viscosity in thin slips, i. e., when the amount of clay was as low as 5% of the mixture. The viscosity increased with the amount of clay in the "slip," but the rate of increase differed for the different clays. One group showed considerably more rapid rise than the others, and this group was recognized to contain the most plastic clays (as judged by ordinary experience). At concentrations of 25% and greater, the viscosities of the several clays differed very greatly; the most plastic clay showed the highest viscosity, while at the other end of the scale a fire-clay of low plasticity showed very low viscosity.

On comparison with the mechanical analyses, the rate of viscosity increase was found to be lower as the amount of residue in the sorting apparatus, or granular matter, was greater. Fineness and uniformity favored high viscosity, i. e., high plasticity.

EFFECTS OF PREHEATING.—Separate samples of the 14 clays were heated to 150°, 200°, 250°, 300°, 350° and 400° C. for several hours. Then the specific gravity was taken of each sample after crushing to pass a 60-mesh sieve; the measurement being made by pyknometer, the influence of residual pore-water ought to be eliminated in large measure. Yet the results show that the specific gravity was higher for the preheated than for the simply dried (normal) clay, and was higher the higher the temperature of preheating. Averaging Mr. Bleininger's results, we find:

AVERAGE SPECIFIC GRAVITY OF NORMAL AND PREHEATED CLAY.

Normal	150°	200°	250°	300°	350°	400°
2.591	2.598	2.643	2.650	2.652	2.675	2.666

The effect on mechanical composition was studied by preheating four samples to 300° and analyzing as before, in comparison with normal samples. In all cases the percentage of overflow or fine matter was markedly decreased by the preheating:

PERCENTAGE OF FINE MATTER.

Normal clay.....	66.72%	80.37	61.66	87.52
Preheated clay.....	44.13%	70.40	28.23	77.17

Correspondingly, the residues in the sorting apparatus were greater for the preheated samples. This points to an aggregating effect of the preheating. It was noted in the series of tests for shrinkage, that in the higher preheatings the clays tended to become granular, and finally "appear to be sandlike and more or less inert in the presence of water."

In harmony herewith is the fact that the water-carrying capacity, i. e., the percentage of water required to temper the clay to the right plasticity for proper working, was found to be less for the preheated clay than for clay merely dried at low temperature. Judgment was the only means of determining when the best plasticity was attained, but it was satisfactory as the clay when near the proper condition was very sensitive to changes in amount of water. Clay which upon normal drying required 50% of water, took only 40% after preheating to 300° C. The decrease was not, however, proportional to the degree of preheating, but usually a larger decrease was produced by raising the preheating temperature from 200° C. to 250° C. than by any other 50° increase; in some clays the interval of greatest decrease was that of 300°-350°, and in some the interval 350°-400°.*

Similarly the drying shrinkage was decreased, the most marked effect occurring in the interval 250°-300° C. for most clays. On the average, the shrinkage was reduced by nearly two-thirds, for preheating to 400° C.

By making simultaneous measurements of shrinkage and water loss during drying, several clays were examined for relation of pore water to shrinkage water after different degrees of preheating. It was found that the shrinkage water as well as the total water decreased and the pore water increased, as the preheating temperature was higher, with indications that if the preheating were sufficiently high all the water would be pore water, the drying shrinkage being zero.

The rate of drying was *not* affected, curiously enough. Preheated clay, while holding less water at plastic stage than normal clay, took just as long to reach constancy of weight when dried at fixed moderate temperature.

As might be expected, the tendency of clay pats to crack in drying, which characterized all the excessively plastic clays used in these tests, was almost completely cured by the preheating. This was demonstrated by a large series of tests. But the reduction of plasticity resulting from preheating had the effect of increasing the friction when the clay was forced through a die, and thereby producing strains in the extruded clay. It follows that good lubrication of the die is important when using preheated clay.

The cohesive strength of the clays, in wet condition, is doubtless also reduced in harmony with the coarsening produced by the preheating. The effect was examined for two clays. After preheating they were made up to the consistency required in the "soft-mud" process of brick-making, and were molded in wooden brick molds. They showed "a decided tendency to slump" and were weak enough that the shrinkage strains in drying produced bad cracking and checking. But when these same preheated clays when worked through an auger machine, where less water is required than for soft-mud working, they dried without trouble. The author remarks further that:

> In tempering preheated clay the point of proper stiff plastic consistency is defined more sharply than with the normal material.

As already remarked, no tests of strength of the clays in dried or baked state were made, so that the effect of the preliminary heating upon the finished product is not known. It is stated, however, that while the drying shrinkage is decreased in preheated clay, the shrinkage of vitrefaction may be increased, due to the relatively larger pore space in the dry preheated material.

The viscosity of slips of preheated clay was not measured. Judging from the granulometric analyses and the absorption and shrinkage tests, however, it is to be assumed that the viscosity was reduced by the preliminary heating.

*Whether the qualities of water-absorbing capacity, plasticity, fineness, etc., would be restored by thorough mechanical working of the preheated clay was not investigated. It is known that some natural clay substances (shales, for example) have such a close structure (or we may say are "set" so thoroughly) that they absorb little or no water until after grinding and pugging. Materials of this kind have either no initial plasticity or at best a very feeble plasticity, until this quality is developed by the mechanical treatment.

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On various occasions in the past four years, we have described the researches which have been made into the electrolytic destruction of specimens of concrete with iron imbedded in them, and in the recent issue of June 8 we described the first case of actual trouble in a reinforced-concrete building which had been reported. In the present issue we describe a series of experiments which was carried on in the laboratories of the University of Vermont, and which is particularly interesting in that they are extended studies from points where previous investigators have left off, and as they seem to throw a little light, first, on the seat of the stresses which result in disruption of the concrete and, secondly, on the ways in which these stresses are developed.

It has been said that in all the experiments along this line, carried on variously about the country, there was a needless and perhaps a wasteful duplication of effort. In the earliest studies of such a new and alarming phenomenon as the electrolytic destruction of reinforced concrete, such a duplication of efforts, however, is not without great benefit in producing a mass of corroborative evidence of trouble. A better understanding of the phenomena involved is to be secured, from now on, by pushing investigations in a multitude of directions and using the investigations which have been reported as starting points as has been done in the series reported from the University of Vermont.

A study of the results of these experiments, shown elsewhere in this issue, leads to the belief that there are two distinct kinds of disruption of reinforced concrete, due to straying electric currents. One results from what we may call a "heavy" current density of the vagrant electricity in the structure. The current, in this case, may be direct or alternating, and, if direct, it may flow in either direction with the same result. The action seems to be the result of local thermal expansion; at least, it is accompanied by rise of interior temperatures. The second type of disruption may occur without thermal effects where direct current passes from iron to wet concrete. This kind of destruction is developed in the course of time with what we may call low current densities, and it seems to be immediately caused by the formation and accumulation of iron oxide in the concrete, but in the vicinity of the anode. The dividing line between "high density" and "low density" in these two cases has not yet been determined, and it is to be expected that a particular failure may show both types of action.

One of the surprising results of the tests reported is that practically the same action was shown with imbedded carbon anodes in place of iron. It was expected, of course, that the carbon would not have been affected. If the carbon had not been affected but the concrete had been weakened or disrupted, then we might have laid the cause of these failures to some action of the current on the concrete itself. But as the carbon electrodes were decomposed and the decomposition product was disseminated throughout the concrete in much the same way as iron oxide, we can believe that the carbon compound acted in precisely the same manner as the iron oxide. The net result of this is that the iron oxide still has to appear as the active material agent in the "electrolytic" destruction of reinforced concrete and the electric current is blamed for the damage only inasmuch as it is its presence which brings about the production of iron oxide.

Additional reassurance is given by these experiments as to the structural safety of reinforced concrete where the vagrant currents are alternating. The time element entering into all the experiments that have been made with alternating current, however, is so small that the last word has not been said on this point. It is well to guard against all sorts of stray currents.

In conclusion, it seems only necessary to call attention to the fact that our recent conclusions (Eng. News, June 8) are unaffected in that the practical safety of any reinforced-concrete building probably will be secured if the concrete can be kept fairly dry, and if all chance voltages are prevented from playing in or on the members of the structure.

As our readers are well aware, Engineering News has for years been industrious in pointing out the errors and dangers in the waterway propaganda which has been carried on so extensively during the past decade in the United States. Our position on this subject fairly represents, we believe, the position of the great majority of members of the engineering profession who have given intelligent and unprejudiced study to the problem.

It is of interest to note that our British contemporaries, "The Engineer" and "Engineering," which hold the premier position as representative journals of the engineering profession in Europe, assume a practically identical position with our own in the discussion of waterway questions.

London "Engineering" for June 16 devotes a page or more to a scheme much discussed in France just now for making Paris a seaport. As a matter of fact, the River Seine is already navigable for fair sized vessels between Paris and the sea. Many years ago the Seine was improved by dams and locks, and there is an available depth of nearly 12 ft. of water between Paris and the English Channel port at Rouen. This waterway carries an extremely heavy traffic, amounting at present to about 11,000,000 tons per annum.

It is very likely true that the traffic on this waterway fully justifies the expenditure which has been made upon its construction and maintenance. The waterway advocates, however, now propose a far more radical scheme for improving the river. They propose to make a channel with a minimum depth of 20 ft. 4 ins., with locks of 26 ft. 3 ins. depth over the sills, the channel to be ultimately dredged to this greater depth if the traffic should require it. The river channel would be given a width of 115 ft. in the straight reaches, widened to 148 ft. on curves. In place of the eight dams between Paris and the sea, four dams would be constructed, each having a head against it of from 19 to 23 ft. The locks proposed at these dams would have a length of 525 ft. and a width of 98 ft. It is claimed that with these improvements cargo steamers would be able to make the distance from Rouen to Paris in about 17 hours. Our contemporary, however, thinks this estimate too low.

The total cost of carrying out this navigation improvement is estimated in the neighborhood of $60,000,000. Detailed surveys and estimates have not yet been made, however, and our contemporary thinks that the final cost might easily reach $80,000,000.

Our contemporary states that the General Committee of the Ponts et Chaussées, which is, as our readers know, the real engineering authority of France, is adverse to the scheme. It is pointed out that, in order to pay a reasonable interest on the cost, the toll charge on the traffic would have to be so large as to wipe out the saving in cost of transport which the large channel might produce compared with the present channel.

One serious drawback to the scheme is that the larger vessels would be obliged to end their journey at a port to be created in the suburbs of Paris, and could not deliver their cargoes close to final destination in the city itself, as do the present smaller sized vessels.

Our contemporary sums up the situation by remarking that an improved waterway working at a loss will no doubt be found a too expensive luxury.

One of the most interesting and promising schemes for river regulation that has been brought forward in a long time seems now in a fair way to reach realization in western Pennsylvania. A brief reference to this scheme was made in these columns several weeks ago, but it deserves greater prominence.

The scheme is promoted by the Manufacturers' Association of Beaver County, Pa., which has issued a pamphlet* with the unique title, "Pymatuning—A Conservation Necessity." Briefly summarized, the scheme is to create a storage reservoir on the headwaters of the Shenango River. The preliminary investigations which have been made indicate that the low-water flow of the river, which at present falls as low as 20 cu. ft. per sec. in the driest months, can be increased by the proposed storage reservoir to at least 400 cu. ft. per sec.

There is, perhaps, hardly a place in the United States where replenishing the low-water flow is as important commercially as on the Shenango River. The Shenango Valley is one of the great centers of pig-iron production. The water of the river is used for cooling the blast furnaces, and in dry, summer weather the water of the river is used over and over again until it has at times reached a temperature as high as 140° F. Further than this, the limitations produced by this excessive temperature of the river compel the shutting down of a considerable proportion of the blast furnaces during the dry months of summer and fall and limit the further increase of the pig-iron industry in this district.

The total cost of creating the storage reservoir for regulating the river flow has been estimated in round figures at $500,000, and the property to be benefited by this river regulation is said to be valued at over $125,000,000. Besides the benefit of maintaining the low-water flow, the flood heights will be somewhat reduced by the proposed storage reservoir. It is estimated that the present maximum flood flow of 13,000 cu. ft. per sec. may be reduced to 11,000 cu. ft. per sec. Inasmuch as it is the last foot or two of flood height which does the greatest amount of damage, this reduction in maximum flow will be a very important gain.

The preliminary work done by the Manufacturers' Association is now to be followed up by a survey under direction of the State Water Supply Commission, of which Mr. Farley Gannett is Engineer. A bill has just been enacted and signed by Governor Tener appropriating $10,000 to defray the expense of surveys and estimates.

We pointed out in an editorial in our issue of June 1 that the proposed storage reservoir would

*Readers who would be interested in fuller particulars of the scheme are advised to address Mr. F. L. Kennedy, New Brighton, Pa., with a request for a copy of the pamphlet. The methods by which the merits of the scheme have been made clear to lay readers may interest other engineers who have similar tasks in prospect.

extend across the State boundary into Ohio and its construction might raise the question of relative State rights over flowing waters. The Shenango River, which is to be regulated, also crosses at one end in its course into Ohio, but returns again, after flowing a short distance, into Pennsylvania. It is to be hoped that interstate complications may not interfere with the success of the enterprise.

The city of Carbondale, Pa., is advertising that it will receive sealed bids "for the services of a consulting engineer to prepare plans for a comprehensive system of sewerage and sewage disposal works." The engineers who bid on this job must put up a certified check for $50, to be forfeited if they fail to contract to do the work within ten days from the award and to complete the job within 60 days. In any event the engineer is to get no money for his work unless and until his plans receive the approval of the State Health Commissioner of Pennsylvania.

We have many times pointed out the absurdity of such schemes for buying engineering services at auction. We have shown that cities which attempt to buy professional services as they would buy a piece of machinery are pretty certain to get professional services which cannot be rated much higher than machinery.

But our protest in these pages furnishes no effectual remedy of the trouble; and we wish to raise the question whether engineers have it not in their own power after all to provide an effective remedy? Suppose there were a society of engineers so organized and so conducted that its first and most important business would be *to protect the interests of the engineering profession.* Why should not such a society on being notified send a representative to Carbondale or to any other city or to any employer of engineers who should attempt action calculated to injure the engineering profession?

It must be remembered that the city authorities who framed the above advertisement did it, without doubt, because they knew no better. They did it because they did not know the right way to go to work to engage competent engineering advice. If a responsible representative of a national society of engineers were to go to Carbondale, he could easily show the city authorities that their scheme is not only injurious to the engineering profession but calculated to work serious injury to the public. An incompetent designer of a sewerage and sewage disposal plant may make blunders which will cost the city many thousand dollars to remedy. We make this statement advisedly with knowledge of cities which have had to spend hundreds of thousands of dollars on their sewerage systems which would not have been necessary had the work been more intelligently and ably planned at the start. Much more than the ability to compute pipe capacities and outflow volumes is needed to fit an engineer to design a sewerage system wisely.

Why should not engineers associated together for mutual benefit do for themselves collectively what no one member of the profession, however influential, can do alone? It would require radical reorganization of our engineering societies and shaking of some dry bones, it is true; but is that a strong argument against it?

Some people have curious ideas as to the proper uses of a technical journal. We have before us a letter from a correspondent inquiring whether we have ever published a description of a concrete dam about 15 ft. high and 30 to 60 ft. wide. What use he intends to make of the description of such a dam when he finds it is not stated, but it is a fair guess that he has something to do with the construction of a dam of such dimensions and wants to get plans of an existing structure of similar size, thinking that a dam may be copied as one would copy a house or a machine.

It is quite within the possibilities, we admit, that the general design of a dam for one location *might* be well adapted for another, but there are more cases where blind copying of what had been done elsewhere might result in serious disaster.

Probably our correspondent is not an engineer. Every engineer knows, or ought to know, that every dam, even of small size, is an engineering problem by itself. Foundations and flood conditions which have to be dealt with at a location on one stream are no criterion whatever as to what must be met on some other stream.

Technical journals like Engineering News are intended to aid engineers in intelligent design. They are not intended to enable persons of an economical turn of mind to try to carry out engineering construction without the aid of engineers. Attempts of that sort very often result in disaster.

Economical Freight Handling at the North River Water Front, New York City.

Plans for bettering the freight terminal facilities at the Port of New York, which have been discussed at intervals for the past thirty years, are again commanding public attention, largely as a result of Dock Commissioner Calvin Tomkins' energy in studying the problem since he assumed office and endeavoring to devise plans for its solution.

To a considerable extent the problem is a local one; but reduction of freight terminal expense is being studied in so many cities and is so generally recognized as one of the most important problems now facing the engineering profession that some general discussion in these problems is appropriate. The space available compels us to consider only the main features and also to confine ourselves to the problems in connection with the North River water front.

It is here that the serious congestion, resulting in excessive cost, in handling New York's commerce is being experienced. The old city of New York, as every one knows, is located on Manhattan Island at the mouth of the Hudson, or as it is locally termed, the North River, which here forms a broad deep estuary 3,000 to 4,000 ft. wide between the pierhead lines on either shore. Upon Manhattan Island are concentrated the wholesale mercantile business of the greater city and a large part of the retail business as well, besides the financial and office district, and the hotel and amusement district. The area not occupied by these interests is inhabited by the most densely crowded population to be found in the world, with the local business required to supply this population's wants.

The resulting high values of real estate and high cost of living have driven off from Manhattan Island most manufacturing industries which require large area for economic operations; the few which remain are mere cases of survival. The goods received and delivered on the North River front of Manhattan, therefore, are either those required for consumption by its own population or are high-class mercantile goods. This is not only true of the rail traffic but of the steamer traffic. The steamships landing on the North River water front are the great passenger vessels handling high class freight. The freight steamers of the minor lines and the tramp vessels carrying low grade merchandise land at wharves in Brooklyn or on the New Jersey shore.

The evils of the present situation for which a remedy is sought may be summarized as follows:

The expense of the present system is enormous both to the railway companies and to the shippers. The running of trains of freight cars through the streets, which is still practiced by the New York Central R. R., causes many casualties, besides seriously impeding street traffic, and must be done away with. The use of the piers, bulkheads and slips by the railway companies as freight stations takes up nearly half the North River water frontage and limits the growth of New York's water commerce. There are now applications on file with the Dock Department from steamship companies for 14 more piers on the North River, which cannot be granted.

The various plans proposed to relieve this condition were reviewed at length in our issue for April 13, p. 447. That which has attracted most attention is the proposal of Dock Commissioner Tomkins to construct an elevated freight railway along West St. This is a revival of an old scheme, which has been several times brought forward as a private enterprise. As revived by Mr. Tomkins it has the merit that it is proposed as a municipal enterprise. All railways would be given access to it on equal terms and it is held that the cost of handling freight from warehouses adjacent to the line of this elevated road would be far below the present costs.

With the general principle urged by Mr. Tomkins, that the city should control the gates through which its commerce passes, we are in hearty accord. Certainly if a freight railway is to be built along the North River water front for the use of railways generally, either on an elevated structure or in a subway, the city should own and control it and should give all railways equal rights to its use.

But it is one thing to offer all railways equal rights to the use of such a road and quite another to actually place them on an equal footing. The fact is that an elevated freight road down West St. would actually be an extension of the New York Central Ry. since its tracks would connect with the tracks of that company at the northern terminus. Since the railways terminating on the New Jersey side of the North River could only reach this road by transferring their cars on floats across the North River, they would be heavily handicapped in the use of such a road, even though they should be granted an equal right over its tracks.

Naturally, therefore, all the railways entering New York from the West oppose the elevated railroad scheme, and declare their unwillingness to make use of it even if it is constructed. The New York Central company, on the other hand, favors the elevated freight railway, but wishes to build and control the line itself.

Suppose, however, that the city, by shutting off the railways from their present facilities for freight handling could compel them to make use of the proposed municipal elevated road. Would such action be for the benefit of the city's commerce? Would the proposed line actually operate with economy and success?

It appears to us that there are grave doubts, first *as to the traffic capacity* of the proposed elevated freight railway and second, since such an expensive plant can only show good economy if it handles a huge volume of traffic, as to the possibility of handling freight over such a road economically.

It has been estimated that if all the railway freight entering and leaving New York were to be moved over the proposed elevated tracks, the movement would amount to an average of 2,000 cars daily each way. If it were possible to make up long freight trains and run them as they are run on the open road of a regular railway line, then a single pair of tracks would easily furnish the necessary capacity to move this number of cars; but it is impossible to make up trains of any considerable length on Manhattan Island. There is no yard room available in which to do it.

Further than this, the train movements over the elevated road would be subject to frequent interruptions if trains were allowed to enter and leave the road at various points. Many enthusiastic promoters have pictured the possibilities from an elevated road on West St. They have shown huge warehouses lining the street, with branch tracks running into them and giving them all direct connection with the elevated line.

But such a scheme is only a promoter's dream, impossible of realization. If West St. were lined with factories and warehouses, each having its private switch branching off from the main line, the interruption to the movement of trains would be so great that the road would be in a perpetual state of congestion and blockade. Engineers familiar with the layout of railway yards know that factory and industrial sidings should be led off from yard tracks and not from the main line, wherever possible. But on an ordinary railway which can handle long

trains of a thousand tons or more, traffic congestion is nothing like as great as it would be on the proposed elevated roads, where train lengths could hardly exceed five to ten or a dozen cars.

The engineers who have worked on Mr. Tomkins' elevated railway scheme have appreciated to some extent the necessity of keeping the main line of their road clear of switching movements, and have provided additional tracks on the elevated structure to be used for switching purposes. Thus the modest double-track elevated structure, which might be permitted along the broad marginal way with comparatively little injury, becomes a four-track or six-track structure. When we add to these tracks the sidings and branches and spurs that would be necessary to reach buildings, yards and freight stations along the line and the necessary inclines to enable trains to pass between the elevated structure and the ground level below, it is evident that a large part of the marginal way would be covered by a broad viaduct, which would exclude the light and obstruct the street with its columns. That such a structure would greatly interfere with the use of the street below is evident enough. Its construction would also involve quite serious difficulties on account of the very heavy column loads that would be imposed and the poor character of the foundations.

It may be said, however, that the proposed elevated railroad could be made successful if few or no warehouses were connected with it and it were made simply a through line leading to the proposed great union stations, two or three in number, for the receipt and delivery of freight intended for any and all railways.

In answer to this we invite contemplation of the task of receiving incoming trains at these stations and making up outgoing trains at the rate which would be necessary to move the required volume of traffic. The necessary room to sort and store the cars could not possibly be furnished.

In addition the concentration of all the trucking traffic receiving and delivering freight at one or two or three centers would produce congestion in the streets adjacent to them which would in itself make the whole plan a failure. The conflagration risk inseparable from such huge warehouses with their varied contents, much of it highly inflammable, is not to be overlooked.

These objections and difficulties apply not alone to the proposed elevated railway line. They apply with even greater force to the proposals for underground freight railway lines on West St. Building additional tracks and sidings and yards for such a line is much more expensive than for an elevated road.

In our opinion, under the conditions existing on Manhattan Island the cost of land is too great to permit the construction of railway yards, either on the surface, on an elevated structure or in subways, of sufficient extent to make it possible to sort and distribute cars and make up trains of sufficient length to enable any sort of railway line along the North River water front to be operated with economy. We know of no place anywhere in the world where such a task has been successfully accomplished.

It is recognized by experienced railway managers that ample yard room is a necessity for the sorting of arriving trains and the making up of leaving trains in all railway operations. Yard room is a necessity even for the operation of city passenger railways, and for passenger terminals; but for handling freight the mileage of yards must be multiplied many times.

These facts are little understood by the general public and even by business men. Schemes have been proposed again and again to utilize the tracks of underground or elevated passenger railways for transporting freight cars direct to the heart of a city, or to build special freight lines of similar construction. The inherent difficulty in every such scheme is the lack of yard room, the impossibility of making up and moving long trains and the resultant lack of capacity and high cost.

If the above analysis be accepted as sound, it follows that the construction by the city of the proposed elevated railway on West St. would be a risky financial experiment and that a probable result would be the permanent injury of the waterfront through the obstruction and darkening of the marginal street by the elevated structure. It is probable also that, instead of securing the desired end of reducing the cost of freight handling in Manhattan, the cost of handling freight over the structure would be actually greater than by present methods. It follows, also, that any scheme should be looked upon with grave doubt which proposes the movement of freight cars over railway tracks on lower Manhattan Island.

The so-called "unit terminal system," designed by Messrs. E. P. Goodrich and Harry P. Nichols, and recommended by a Committee of the Board of Estimate and Apportionment, has the merit that it does not confine the traffic entering and leaving Manhattan to a single channel. For its greatest success, however, it ought to be adopted by all the railways in cooperation.

So long as every railway reaching New York City has to have its own independent freight receiving and delivering stations located at two or three or more different points along the North River water front, the terminal expenses of both railways and shippers must inevitably be exceedingly heavy, and substantially as much of the water front must be devoted to railway traffic as at present. On the other hand too great concentration in freight terminals is inadvisable as was just pointed out. There ought to be at least four different stations between the Battery and 60th St., where railway freight could be received and delivered. Any less number means added expense to merchants for trucking, so long as present conditions continue.

The opportunity would seem to be open in New York City for the organization of a joint terminal company, which should operate in a similar manner to the Association formed by the railways terminating in St. Louis. It should carry on the entire business of handling freight, from its delivery by the railways in their terminal yards on the west side of the North River, including its passage across the river by lighter or car float, and its final delivery at freight stations to the consignee. For outgoing freight such a company would receive the goods from the shippers and transfer them to the yards of whichever railway could carry them most directly to destination.

In view of the competitive conditions still existing in the railway freight business, such a suggestion may seem like a wholly impossible proposition. On the other hand, these competitive conditions are really not an essential feature of railway operation at the present day. Under the establishment of public control by state and federal commissions, the need of competition in railway service as a protection to the public has been practically eliminated. The economies which could be introduced by joint operation of terminal freight handling are so great that the benefit to both the public and the railway companies would far outweigh any loss which would result from the elimination of competition.

Supposing it were possible to organize such a joint freight terminal corporation as we have suggested, what means could it take to economize the cost of freight handling to and from Manhattan Island? It will be conceded in the first place that the present system, under which the piers are used as incoming freight stations and the bulkheads between them as receiving stations for outgoing freight, while the water front is filled with car floats being loaded and unloaded, is a wasteful use of the floating equipment and of the water front of the city.

It is probable that material economies could be gained by adopting some features at least of the "unit terminal" system devised by Messrs. Nichols and Goodrich; that is to say, by establishing freight stations on the opposite side of West St. from the water front and bringing the cars to and from them over elevated tracks. There might conceivably be four such union terminal stations for the receipt and delivery of rail freight consigned to any railway along the west shore of Manhattan Island. Such a distribution of stations would materially shorten the trucking distance now necessary for shippers in order to reach all the different railway companies. From each of these stations loaded cars would be transferred to each of the various railways terminating on the west side of the river, and also probably to the railways reaching New York from the north.

But the greatest saving of all would be effected, in our opinion, if such a terminal corporation should take up in a systematic manner *the collection and delivery of freight from the shippers.* The greatest expense in the handling of freight in the Borough of Manhattan is the trucking between the warehouse or factory and the freight station. While many of the horse-drawn trucks used in Manhattan are capable of carrying a load of from two or three tons, the average load carried is far below this. It is doubtful whether the average load carried to the outgoing freight stations is as much as 1,000 lbs. Yet as much time is consumed by the truck and the driver in delivering a small package from the warehouse to the freight station as if it were carrying a full load.

We are on the threshold of a revolution in the haulage of freight through city streets. The horse-drawn truck is soon to be replaced by the motor-driven truck; and for the most economical use of the motor-driven truck it is essential that large loads shall be carried. It is probable that a few years hence will see in common use motor-driven trucks capable of carrying from five to eight tons of freight through city streets at good speed.

While there are perhaps comparatively few shippers whose business is sufficiently large to enable them to make economical use of such trucks, a freight terminal company could operate such vehicles and handle freight from the car to the warehouse, and vice versa, at far lower cost than is involved in present methods. If and when freight can be handled by such vehicles, the next step will be to reduce to a great extent the movement of freight cars across the North River on floats and deliver goods instead from the warehouse in New York directly to the freight houses of the various railways located on the west side of the river. With horse-drawn vehicles it would not be possible to cover such a distance with such loads economically. With motor traffic the condition is entirely altered.

An instructive illustration of the possibilities of motor traffic is shown by a recent advertisement of a motor-truck building concern. It is claimed that a load of goods was carried from a store in New York City to a store in Philadelphia. The trip was made in about nine hours, and the total cost incurred was less than the cost to have carted the goods to the railway station and sent them by freight, with the cartage at the other end and the necessary expenses in repeated loading and unloading.

It may be said that the transfer of loaded motor trucks across the North River by ferry would not be as economical as the present system of transferring freight on car floats. If the car float handled fully loaded cars, this criticism would doubtless be sound. As a matter of fact, however, the freight cars carried to and fro across the North River contain on the average only a small percentage of their capacity—probably not very much more than the eight tons which we have suggested as a possibility for a motor freight-truck.

Bearing in mind the celerity with which the ferry-boats which handle ordinary vehicles can be loaded, and unloaded, and the cost involved in distributing cars from the yards to the floats, handling them on and off the floats, etc., we believe there would be a large saving in the motor-truck plan of handling goods which is here suggested.

While it is somewhat aside from the main subject here discussed, we may call attention also in this connection to the need of a reform in railway freight tariffs which shall separate the charge for terminal expenses from the charge

for hauling over the road. The merchants and politicians of New York are complaining of the differential imposed upon its commerce by railways, and wholly ignore the fact that the railways are *entitled* to charge a higher freight rate to any point where the cost of terminal handling is excessive.

We have before advocated in these columns the division of terminal charges from road charges in freight tariffs; and New York is an excellent place for the reform to start. At present, for example, the railways charge the same rate of freight to Jersey City as to New York, ignoring entirely the heavy expense they are under in transferring from across the river. If this terminal charge were made different for Manhattan and for Jersey City, in accordance with the difference in expense involved, it is probable that the present congestion of Manhattan freight stations would at once be relieved. Many shippers having a sufficient amount of goods would carry them across the river and ship them from Jersey City instead of New York.

There is a further reason why the railways ought to assess a separate terminal charge. Cities which have by proper foresight arranged an economical system of freight handling would reap the benefit to which they are entitled, while cities where conditions have grown up which make a heavy cost of terminal handling a necessity would understand their obligation to institute reforms and permit more economical methods to be introduced, if they desired to have more favorable railway rates.

Discussion of the Questions Raised in the Above Editorial.

In order to obtain expert opinions on the subjects discussed in the above editorial, we sent out advance proofs of it to several well-known engineers who are by their experience in railway work particularly competent to render an opinion, and we print below the replies received.

The first of these is from Mr. Wm. J. Wilgus, M. Am. Soc. C. E., who as Chief Engineer and later as Vice-President of the New York Central & Hudson River R. R. planned the great improvements which are now being carried out in connection with the Grand Central station in New York City and the electrification of the railways reaching it. Mr. Wilgus has given, probably, the most thorough study to the question of economic freight handling facilities in New York City of any engineer, and by his extended experience and access to official records is able to speak with greater weight of authority probably than any engineer that could be found anywhere. We print his letter as follows:

Sir: In response to your request for my comments on your editorial respecting the more recent aspects of Manhattan's freight problem, I would like to preface my remarks with an expression of pleasure that a matter of such vast importance is at last open to discussion in an engineering forum.

It seems to me that any plan worthy of investment by the city of some $100,000,000, as proposed by Dock Commissioner Tomkins, should not alone dispose of tracks at grade and relieve the waterfront, but it should also enhance the commerical prosperity of the port by decreasing:

(a) Cost of terminal service from the receiving yards in New Jersey to the consignee, estimated to now aggregate $1.49 per ton;
(b) Delays; and
(c) Street congestion.

As regards the *Tomkins* plan, the question is—Does it meet these conditions?

It is proposed that cars shall be floated from the railroad terminals in New Jersey, an average of from two to three miles upstream, and then be hauled on an elevated railway an equal distance in the reverse direction, or a total of from four to six miles, as contrasted with the present cross-stream floatage of a little over one mile. The car floats from eight different railroads are to converge into a section along the waterfront between 30th and 40th Sts., where the cars, after being placed on shore, are to be switched through classification and storage facilities that are plainly inadequate, and then are to be raised on ramps to elevated tracks, incidentally clashing with traffic moving in the opposite direction. The cars are then to be moved to elevated terminals in lower Manhattan on the east side of the marginal way, where the city blocks are much too small for that purpose and where the use of the adjoining narrow streets by trucks will congest the surroundings and incidentally choke the outlets from the wide marginal way to the interior of the island.

Various estimates in detail have been made showing that this plan will result in an increase in the cost of service of from 40 to 80 cts. per ton, or a total of say $2.09 per ton as against the estimated present cost of $1.49 per ton. The extra time needed for moving cars over the circuitous route will entail the closing of freight house doors in Manhattan at least as early as one or two o'clock in the afternoon, instead of the present hour of five, in order to have freight delivered on the New Jersey side in time to leave on night trains.

Summed up, this plan apparently promises an increase of about 40% in terminal charges instead of a decrease, and also an increase in delays and congestion. Under these circumstances it is difficult to see how the city is justified in proceeding with the scheme.

The *Goodrich-Nichols* plan avoids many of the objections urged against the Tomkins plan in that it does not impose the circuitous river route; nor the long expensive elevated railroad haul; nor the confusion incidental to an attempt to handle several thousand cars daily from eight different railroads at a battery of float-bridges having insufficient yard facilities; nor does it deface, obstruct and darken the city's handsome marginal way with a continuous elevated structure in the manner that you have so clearly outlined.

This plan, however, does retain the present evils of costly cartage on the city streets and break of bulk from cart to car in Manhattan, with attendant expense, congestion and delays; it still leaves the city subject to the interruption of supplies during obstruction by fog and storm on the river; and it offers no hope of a reduction in the cost of service.

It may be said that this plan accomplishes the purpose of removing the tracks at grade and that it reduces the occupancy of the waterfront for railroad purposes, but it leaves the other *desiderata* of cost of service, delays and congestion in *statu quo*. Should not the city attempt to solve this problem for all time in a way that will assist in maintaining the prestige of this port in competition with the other great ports of the world?

Your suggesion of cutting out the use of the waterfront for railroad purposes by transporting freight between the railroad terminals in New Jersey and the consignee, goes to the heart of the problem. Why should the bulky, cumbersome, standard railroad car be brought to congested Manhattan, to have its contents there transferred to carts, on land worth several hundred thousand dollars an acre and urgently needed for other purposes, when the cart or truck can just as well cross the river and meet the car at the natural termini of the railroads, where land for transshipment is plentiful and cheap?

You suggest that modern motor trucks perform this service from the door of the shipper to the railroad termini, via floats and street surfaces. May I suggest an additional step that will still further eliminate unnecessary cost, delay, risks and congestion? This was proposed by me some time ago as a cartage subway system, the elements of which may be briefly summarized, thus:

Substitute a tunnel beneath the river for the floats on the surface;

Furnish small subways under the sidewalks adjoining the cellars of business blocks that are now in use for the receipt and delivery of freight in the commercial center of Manhattan;

Provide compact transfer terminals with mechanical devices along the main stem of the small subway at frequent intervals in the residential and minor business sections of the island, where the vehicle bodies may be lifted from the trucks and either held temporarily in storage or placed directly on skeleton auto-trucks without break of bulk, for distribution on street surfaces to consignees, in the same manner as is now done with furniture vans from Europe and by contractors on work like the Pennsylvania R. R. tunnels under 33d St.;

Operate the motor trucks, not singly with a separate motorman for each, but in trains with a single man at the head under the well known multiple-unit control system, which dispenses with the need for locomotive switching; and finally

Operate this system of motor trucks under a central directing agency, with uniform schedules of charges for similar classes of service between the consignees' door and the railroad terminal.

If independent units can be successfully operated haphazard on the street surface, groups of units intelligently dispatched, free from harbor and street interruption and with mechanical appliances for prompt and economical transshipment, should be at least equally practicable.

A careful analysis of all aspects of the multiple unit motor truck plan, engineering, operating and financial, indicates that it is entirely feasible and that it will

(a) Decrease the cost of service from the present rate of $1.49 to $1.08, a saving of 41 cents, equal to 30 per cent.;
(b) Decrease delays; and
(c) Decrease congestion.

In conclusion, may I add that it seems to me that a transportation problem so intricate as Manhattan's, involving, no matter what plan is adopted, a radical departure from existing ways of handling a traffic of over 25,000,000 tons annually and affecting the prosperity of the leading port of the world, should be considered and finally passed upon by a commission of able and experienced transportation engineers?

Yours very truly,

Wm. J. Wilgus.

165 Broadway, New York City, June 15, 1911.

Mr. Geo. B. Francis, M. Am. Soc. C. E., of Westinghouse, Church, Kerr & Co., has had a large experience in railway terminal problems and has already gone on record as a member of a committee of the Merchants' Association of New York which adopted resolutions generally favorable to Commissioner Tomkins' plans. He had also much to do in connection with the work of an earlier committee of the same Association which reported on the subject Nov. 25, 1908.

Sir: I have read with much interest the advance draft of your editorial on "Economical Freight Handling at the North River Water Front, New York City."

This is a subject of great complexity. The fact that plans for relief from present conditions, in one or all particulars, have been presented for a period of 30 years is evidence of the hopelessness of solution, if it is expected that all the evils of the present situation are to be removed by the adoption of some one scheme. If, on the other hand, some one or more of the evils may be promptly removed, by advancing in some direction, such advance is warranted. By taking one step after another, possibly the desired relief may be obtained and the adaptation of some parts of the *many* ideas advocated may be required to the satisfactory solution of all the various parts of the problem.

Unquestionably the first step is the removal of tracks on the grade of the present streets, and still maintain all the advantages that now exist in the convenient handling of the freight traffic for merchants and manufacturers.

The fact that the New York Central Railroad has now some advantages over other Western railroads in serving the community, is no valid reason why the community should be made to suffer in order that other railroads may be on a par with the New York Central Railroad, through the reduction of its advantages.

In the advocacy of an elevated railroad along the waterfront, in place of the surface tracks, Mr. Tomkins is trying to conserve and increase the advantages to the community, by advocating its use by other railroads, so far as feasible, in addition to the New York Central Railroad. The mere fact that this latter road stands ready to bear the expense of construction and maintenance of such a line, for use in connection with its other facilities, is evidence of its belief that

the expenditure is warranted for its purposes alone.

It may be quite true that the elevated road will not have the capacity, nor be able to accomplish all that it is represented for its usefulness, but this is no reason why it should not be built at all.

An elevated railroad can be built which will have a large capacity, and, up to that limit, it would be a useful improvement for the community. If it cannot be made to serve all the railroads, it may be able to serve more than one. If it cannot be made to serve all the warehouses that might be built along the waterfront, it could be made to serve some of them. If it cannot be made to serve all the pier necessities for side tracks, it might be made to serve a considerable number. If it cannot release to water transportation all the waterfront now used by railroad freight facilities, it might release some, and thus accomplish that for which Mr. Tomkins is striving.

An elevated railroad along the route of the present surface tracks in Tenth and Eleventh Aves. might be deemed undesirable, but it would be altogether a different question if it were located in West St.

I am in sympathy with the idea of drayage by means of mechanical power, either by the private owner or the transportation company, and believe that the increased radius of distribution through speed and capacity by power, over horses, is in a measure the same as the increase by means of automobiles over horses or taxicabs over horse cabs.

When all is said and done some of all the facilities now existing, together with some of those proposed, will accomplish some of the desired results, and this is all that it is reasonable for this generation to hope. The ultimate results desired, in any direction, are reached by progressive steps rather than by one immediate step which will settle all things for all times.

Very truly yours,

Geo. B. Francis.

10 Bridge St., New York, June 15, 1911.

Mr. B. F. Cresson, Jr., M. Am. Soc. C. E., Deputy Commissioner of Docks of New York City, has had a responsible part in the development of Mr. Tomkins' plan and is well qualified by his experience as a railroad engineer to discuss the questions we have raised above. Mr. Cresson's response to our invitation follows:

Sir: I am glad of the opportunity to express in your paper briefly some of the considerations which seem to make most desirable the construction of an elevated railroad on the west side of Manhattan for freight purposes, available for the use of all of the railroads doing business in Manhattan. The necessity at the present time for the adoption of some plan by which relief may be had for the congested conditions on the west side of Manhattan and for better and more economical use of the waterfront, is perhaps better appreciated in the Dock Department than anywhere else.

Your editorial makes it evident that the subject has had very careful study, but it may be that some of the factors in the problem have not been duly considered. It cannot be regarded as a local problem, nor one which involves only the matter of railroad freight; it involves in fact the railroads, the coastwise and trans-Atlantic steamships, the Hudson river canal and barge traffic, and it involves the general distribution of commerce in the harbor. The railroad freight which comes from the New Jersey railroads to the waterfront of Manhattan in cars is perhaps the most important local commerce for which the City must provide, being almost entirely for Manhattan itself. The manner in which this business is now done—by means of car floats carrying loaded cars which are unloaded on to the piers and bulkheads and re-loaded there—is no doubt the easiest and quickest method of doing this business, where there is room for it. But at the present time, upwards of 50% of the lower Manhattan waterfront is occupied daily by some 1,500 to 2,000 freight cars.

The west side of Manhattan is without doubt the place where the first-class passenger steamships should dock. It is the most convenient for this service, being in close proximity to the hotels, amusements and railroads. The steamers handle almost entirely high-class freight. The railroads which occupy this Manhattan waterfront are already overcrowded in their present occupancy and their business is continually increasing. If the railroads continue to use this waterfront as they are doing at the present time, it means that more and more of this waterfront must be given over to them in order to allow for their increased business; and to do this means that the ships will have to go elsewhere. To devote this waterfront exclusively to railroad use would result in compelling these high-class steamship lines to go to other parts of the harbor; to South Brooklyn, or Staten Island, or the New Jersey shore, involving additional transfers and delays; or it would result in New York City losing considerable of this commerce in favor of other cities where inducements are being held out to them, in contrast to the lack of facilities which New York can provide under existing conditions.

The surface railway tracks of the New York Central railroad extending from 60th St. to the St. John's Park terminal are another feature of this problem which is of the greatest importance. There is no doubt but that the tracks must be taken up from the surface; but it is also believed that this all-rail connection with lower Manhattan is of the very greatest importance to the city, as it not only serves a very important commercial district, but is also believed, by reason of being an all-rail connection, to have a marked influence upon freight rates. To cut these tracks without an alternative all-rail method will mean that one competitive factor in Manhattan will be removed. Both the report of Commissioner Tomkins and that of Messrs. Goodrich and Nichols recognize that these tracks should not be cut until an alternative method of getting railroad cars to the district about St. John's Park is provided. The cost to the New Jersey railroads of delivering freight on the west side of Manhattan is very great, and without this competitive factor, the present rates might even be increased. It is very evident that the use of surface tracks must be discontinued, and it appears that a subway is not feasible, both from a construction and an operating standpoint, and the only alternative left, if this all-rail connection is to be continued, is an elevated railroad. The New York Central railroad has declared itself willing and ready to build this road with its own money, if the City will permit it to do so. But for the City to give this franchise to the New York Central for its individual use would be to give it a monopoly of one of the most valuable franchises in the City's power to give.

The proposition is, therefore, that this all-rail connection is necessary, and the best means of maintaining it is by an elevated railroad, and this elevated railroad should not be given as a monopoly to the New York Central Company. Provision is, therefore, made in Commissioner Tomkins' plan for an elevated railroad built by and under control of the City, with a transfer bridge installation between 30th and 40th Sts., where cars of the other railroads may be landed and have access to the elevated railroad. It should be noted that in practically every modern port terminal installation, a marginal railroad is provided connecting the various parts which go to make up the terminal installation.

With an elevated railroad running down West St., the easterly side of the street (which is now occupied generally by the cheapest sort of buildings) would be able to develop into distributing centers or warehouse installations, and would make available for use this easterly side of West St., which is now practically unused commercially, owing to its lack of connection with the waterfront. It is believed that if this condition arises, the other railroads will find it very desirable to transfer their freight cars to the easterly side of West St., where they can be conveniently spread out with room for their facilities to expand, and by so doing the necessity for the occupancy of this most desirable waterfront for railroad purposes is reduced and certain additional waterfront can then be given up for marine purposes. There is no ground for disputing the fact that the New Jersey railroads would be at a disadvantage with the New York Central until such time as tunnels under the North River shall be built, when they will practically be on an equal footing. But the fact that this disadvantage to the New Jersey railroads exists will probably lead them to bettering their present facilities, and the city should seek to improve its service instead of depriving itself of one of its most useful freight connections.

The statement is made that naturally all of the railroads entering New York from the West oppose the elevated railroad scheme, and attention is called here to certain conditions which may have some effect upon the railroads' attitude:

(1) If the New York Central shall have to discontinue its tracks at 60th St., it will have to float its freight down the North River and will be put on an equal basis with the other railroads. This may be desirable from the point of view of the other roads, but it does not appear to improve the commercial conditions of the City. Every added facility for the distribution of freight in New York is an asset to the City, and it should not be the policy to remove what the City already has of use. It would also necessitate additional waterfront terminals to be given over to the New York Central.

(2) If the elevated railroad shall be built, and terminals constructed on the east side of West St., the New Jersey railroads will have to transfer their cars to them over the elevated structure. In doing this they will be at a disadvantage with the New York Central until such time as tunnels shall be built.

(3) If the railroads can do their business on the east side of West St. by running their cars over the elevated railroad, the City will be able to use for marine purposes some of the piers which the railroads are now occupying. Some of these piers may be given over to steamship lines which enter into direct competition with the railroads themselves, and the railroads naturally do not desire to encourage competition of this sort by affording the steamship lines better facilities.

The necessity for providing longer piers is another feature of this subject which is closely identified with the general situation. The Secretary of War has granted a temporary permit for the extension of two of the Chelsea piers to accommodate the large steamships about to come to this port. This is a temporary permit only, and, unless the City shall signify some general policy by which it proposes to provide piers sufficiently long to accommodate this traffic, the temporary permit may be withdrawn at the end of 18 months and these long ships will then have to find accommodations elsewhere.

A plan has been made and a request for its adoption is now before the Commissioners of the Sinking Fund whereby two 1,000-ft. piers can be constructed in the near future just south of the Chelsea piers. These two piers will not be sufficient to accommodate all of the long steamships in the future, but they should be able to accommodate them for some time to come. The pierhead line as it now exists between the Battery and Gansevoort St. has a bow inland and it is believed that the Secretary of War will grant permission to straighten this line. When this is done several piers in excess of 1,000 ft. in length can be constructed in the vicinity of Desbrosses St. without cutting back into the marginal way. This, of course, cannot be done until the piers shall become available, and the railroad companies cannot be forced to give up these piers until provision is made for them to conduct their business otherwise, but if the elevated railroad shall be built then the railroads occupying these piers in the Desbrosses St. section may find it possible to surrender them, and in that event a very fine installation of long piers can be built.

As to the capacity and operation of the elevated structure, there is, of course, no room in Manhattan for freight yards, but it should be observed that all the railroads have freight yards on the New Jersey side and trains are made up there and shipped direct to their terminals on the West side of Manhattan; and it is believed that, similarly operated, the trains could be made up in New Jersey and shipped direct over the elevated railroad to terminals in Manhattan without the necessity of railroad yards in Manhattan.

It should be noted that the freight traffic with Manhattan is maximum in the morning in one direction and in the afternoon in the opposite direction, and that at these times of maximum traffic there is very little traffic in the opposite direction, and therefore practically all of the elevated structure can be used for trains in one direction during the maximum periods and the capacity of the railroad under these conditions would be very great.

As to the terminals for the railroads, they can be established by individual companies for their own particular use on the easterly side of West St. wherever they are required, and trains can be made up in New Jersey destined for particular freight stations just as at the present time they are made up for particular piers, and the necessity for splitting up trains with the accompanying necessity for yard room for this purpose in Manhattan would not exist. If union stations shall be placed on the easterly side of West St., certain portions of these union stations can be devoted to each particular railroad. The easterly track on the elevated structure would probably be considered as the switching track and would not generally be used for through traffic.

Mention is made of the difficulty of assembling freight from warehouses should connections be made to them, and this is, of course, recognized, but it is believed can be overcome by proper organization and by installation of a small assembly yard near the transfer bridges, or, what will no doubt ultimately be necessary, a joint assembly yard in New Jersey. The elevated railroad scheme is easily available for joint operation by terminal companies, and it appears probable that it will be necessary to have such a company to operate on Manhattan Island. The transfer bridges and the terminals can be as individualistic as desired, but the operation of the line itself would have to be under the control of one organization.

Reference is made in your article to interference with traffic by reason of the inclines on the marginal way to enable trains to pass between the elevated structure and the street level below; the proposed plan contemplates no such inclines below 25th St. The obstruction which would be caused by reason of the elevated railroad columns would not be serious, and might indeed be a benefit in having a tendency to separate traffic. The construction difficulties as to foundations have been, of course, considered and are not thought to be very great.

Some of the advantages of an elevated railroad for freight purposes along the waterfront are that it ties together practically all of the component parts of the terminal and makes the whole of the west side a joint terminal with connections to railroads, warehouses,

distributing centers and factories, and (if ultimately thought necessary) with the piers. It is capable practically of unlimited expansion; of operation jointly or otherwise; and of great elasticity as to both method of organization and operation. It can be built immediately without interfering in any way with the present occupants of the waterfront; temporary connections can be made immediately to it by ramps from the existing inland railroad yards of the Pennsylvania R. R., the Erie R. R., the Baltimore & Ohio Ry., and the Lehigh Valley R. R., above 23d St. It will have an immediate tenant in the New York Central and will be the means of removing their present tracks from the surface. It will tend to develop the easterly side of West St., increasing thereby land values and tax receipts, and will create a demand for railroad cars from all railroads to terminals connected with the elevated railroad which they will be compelled to supply, and, in supplying these, they will be able to release certain waterfront for marine purposes.

It is admitted in your article that the present system is wasteful of waterfront. Something therefore should be done. The question is, What? Conditions cannot be permitted to continue as they are at the present time. More than one-half of the shipping costs to the merchant are incurred between the waterfront and the factory or warehouse, and a large portion of this is due to delays in truckage, which delays are caused by overcrowded conditions. With room for expansion on the easterly side of West St., these delays could be materially lessened and the cost to the merchants correspondingly decreased. If you recognize that the feature of the Goodrich-Nichols plan is good in that it is possible to establish freight stations on the opposite side of West St., bringing cars to them over an elevated structure, then this same feature is good on the elevated railroad scheme, which does exactly the same thing but in what is thought to be a far simpler manner.

It might be observed that it is possible to construct a transfer bridge installation at the lower end of Manhattan where cars can be taken on to the elevated structure, but it seems questionable if this is a good thing to do.

With reference to the Goodrich-Nichols plan, I will not go into a detailed discussion of it, except to say that the cost of installing the number of "unit terminals" stated to be necessary in their report recommending these, would appear to be greater than for the elevated railroad structure, and the overhead charges for freight would be, therefore, greater under the "unit terminal" plan. The statement is made that the railroads now occupy 23 piers and that with nine "unit terminals" all of this business can be done, and that, therefore, a considerable amount of waterfront can be released; it should be observed, however, that for each "unit terminal," as shown on their plan, the space occupied by two present piers must be utilized, and as the business increased, practically the entire North River waterfront would have to be permanently given over to the railroads. In order to install "unit terminals" certain piers on the North River would have to be abandoned during their installation, and at the present time this could not be done without serious interference, as the conditions are already over-congested. The capacity stated for these "unit terminals" is thought to be far in excess of what they would actually have. It is believed that it would be very difficult to provide in the North River silt a sufficiently stable foundation to carry the "unit terminals" installation with its heavy loading without having local settlements which would tend to disarrange the complicated switching system. The electrical installation would be very difficult. If terminal buildings are built on the easterly side of West St., fed by "unit terminals," the waterfront must be permanently attached to these terminals and the city must lose control of that waterfront permanently. Owing to the very complicated switching system, there would appear to be great danger of tie-ups due to derailments; and the 5% grade leading down toward the end of the pier would be likely to cause accident and difficult operation. It is not believed that they could be operated jointly, and the railroads have all expressed themselves as not favoring that sort of an installation; and, with the railroads not favoring it, how could these installations be built?

Reference is made in your editorial to the matter of trucks delivering and receiving freight from terminals and railroads in Jersey City. It is well known that this matter has been carefully considered by certain of the railroads, but, with the great rivalries which now exist for Manhattan business, it is not believed that this will be adopted except as a very last resort. It would have a tendency probably to increase truckage cost to the merchants at the same time that it would decrease the cost to the railroads. The present ferries in the rush hours are scarcely able now to carry the trucks which come to them, and if to these are added all of the other trucks delivering and receiving freight from the railroad piers, it would require a very large ferry installation. There are many other features connected with the conditions in this port which have a more or less direct bearing on the North River waterfront, but I do not feel that they can be gone into in this article.

The plan of Commissioner Tomkins has been submitted and the details and necessities explained to various commercial organizations, and resolutions have been passed by the following, directed to the Board of Estimate and Apportionment, recommending the adoption of the Dock Commissioner's plan for an elevated freight railroad on the West Side of Manhattan for joint use by all the railroads:

Merchants' Association of New York.

Maritime Association of the Port of New York.

New York Produce Exchange.

New York Board of Trade & Transportation.

Manufacturers' Association of New York.

Merchants & Manufacturers' Board of Trade.

Building Material Exchange.

Mason Builders' Association.

Citizens' Union.

Erie Basin Board of Trade.

The engineers of the Public Service Commission have stated in a recent report:

The plan that results in the best advantage to all the roads and at the same time serves the City's interest, is one which involves the building of an elevated road along the waterfront with the necessary terminal warehouses for the receipt and distribution of all the railroad freight.

The general plan as proposed by Commissioner Tomkins has been worked out by the engineering bureau of the Department of Docks and Ferries and has the endorsement of the Chief Engineer, Mr. Charles W. Staniford, as well as the members of his staff, who have long been familiar with the conditions and commercial requirements of the port.

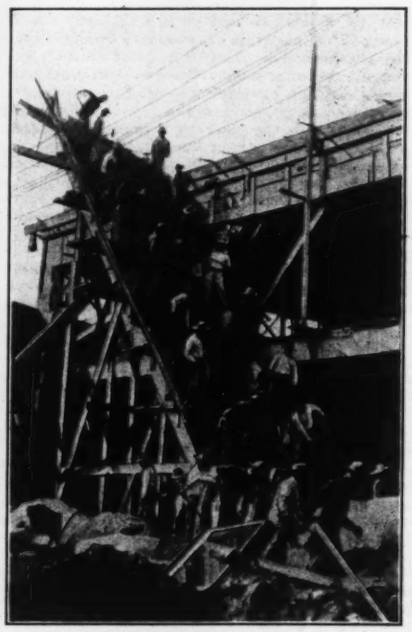
B. F. Cresson, Jr., M. Am. Soc. C. E.
Deputy Commissioner of Docks.

New York City, June 20, 1911.

LETTERS TO THE EDITOR.

A 26-Man-Power Concrete Mixer and Elevator.

Sir: It might amuse some of your readers were you to reproduce in your journal the enclosed photograph of a combined concrete mixer and elevator, which machine



A Mexican Concrete Mixer and Elevator.

was the larger portion of the plant employed in connection with the erection of a concrete building at Guymas, Mexico.

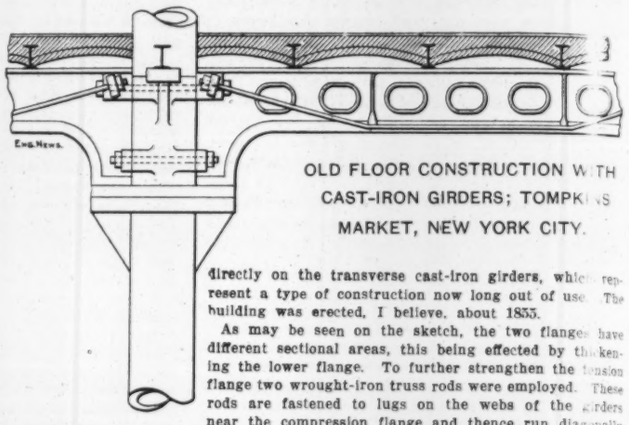
E. G. Tilton,
Chief Engineer San Pedro, Los Angeles & Salt Lake R. R. Co.

Los Angeles, Cal., May 29, 1911.

Cast-Iron Girders of a Half Century Ag

Sir: I enclose herewith a sketch showing the [illegible]reet floor construction of the old Tompkins Market, now [illegible]ding torn down, to be replaced by an annex building [illegible] the Cooper Union.

The floor proper is carried on brick arches a[illegible]ting against the lower flanges of rolled I-beams. The [illegible]rest



OLD FLOOR CONSTRUCTION WITH CAST-IRON GIRDERS; TOMPKINS MARKET, NEW YORK CITY.

directly on the transverse cast-iron girders, which represent a type of construction now long out of use. The building was erected, I believe, about 1855.

As may be seen on the sketch, the two flanges have different sectional areas, this being effected by thickening the lower flange. To further strengthen the tension flange two wrought-iron truss rods were employed. These rods are fastened to lugs on the webs of the girders near the compression flange and thence run diagonally to the tension flange, in which position they are held by two other lugs running transverse to the web and tapering off towards the compression flange; thus producing an effect similar to a queenpost-truss design. At the ends of the girders the lower flange curves downward to form a seat. The girders are fastened to the columns by four bolts passing through lugs on the webs and clear through the shaft of the column.

The span of the girders I should judge to be about 20 ft. The web is lightened by oval holes.

Albert Goertz.
343 East 58th St., New York City, June 4, 1911.

Rapid Concrete Laying In An Arch Bridge.

Sir: What we consider a day's work worthy of note was done by us on June 3, 1911, in pouring the largest of the five concrete arches comprising the 925-ft. reinforced-concrete "Rye Outlet Bridge," a new highway structure being built in connection with Kensico Dam for the New York City water supply near White Plains, N. Y.

The span, which is 127 ft. 7 ins. long, with a rise of 27 ft. from springing-line to crown, which latter is about 175 ft. above the ground, consists of two arch ribs, each 9 ft. wide and varying in depth from 5 ft. at the spring to 2½ ft. at the crown, and contains 365 cu. yds. of concrete.

Work was started at 4.30 a. m. and completed at 12.30 noon, the two mixers working just eight hours each.

The pouring was made unusually complicated because the specifications required a 3-in. mortar facing of cement and ¾-in. crushed pink granite, to be brought up in advance of the concrete on all exposed surfaces, which are later to be tooled.

Over 2,600 bags of cement were used on the one arch.

Webber Construction Co.,
H. A. Hyman, Supt.

White Plains, N. Y., June 16, 1911.

The Ney Patent on Concrete.

Sir: One Alexander D. Ney, of this city, has instituted a suit in the United States Circuit Court for this district against the City of Aurora, charging that said city has infringed his patent, Number 939072, said patent being a patent on a "Rock-like Substance." This patent was issued Nov. 2, 1909, and I herewith enclose you a copy.

In preparing the defense of the City of Aurora to this case, I find in your valuable paper of Dec. 9, 1909, this patent discussed editorially, the nature and tenor of which editorial has given me some pleasure and comfort.

It is needless to say in this connection, that should Mr. Ney prevail in this suit, it would be very difficult to predict what would happen to the future construction of buildings, etc., in America where the so-called "wet mixture of concrete" is employed.

The City of Aurora will use every endeavor to defeat this patent by showing prior art and publication and I am sure that you would render very valuable assistance to me and the country in general if you could supply me with such data at your command, where the so-called "wet mixture" described by Mr. Ney has been discussed in your paper or any other publication prior to Nov. 2, 1909.

On June 13, I attended the semi-annual convention of the cement manufacturers of the United States at Kansas City, Mo., and directed the attention of the delegates

present to this patent and the pending suit referred to above. These gentlemen assured me that they would lend every assistance to defeat this suit in the way of securing evidence of the prior art of making concrete, and I am now anxious to obtain such information as may be had in the way of prior publication and discussion of the "Rock-like Substance" patented by Mr. Ney.

C. F. Clyne, City Attorney.

Aurora, Ill., June 20, 1911.

[We quote the principal clause of Mr. Ney's patent specification, wherein he defines his invention as follows:

In the making of concrete, it has hitherto been the general practice, in mixing the materials, to make the mass as stiff as possible, using only sufficient water to cause adherence of the materials together, and thereafter tamping the materials to cause the mass to be as compact as possible in its relatively dry condition.

In the operation of making the product of the present invention, a radically different method is followed in that an abundance of water is employed in order not only to permit gravity to bring the mass to a solid, compact condition, and thereby dispense with the ramming operation, but also to provide sufficient water for the purposes of crystallization. The process of forming the present product is essentially a wet process as distinguished from the relatively dry process employed in making concrete.

If our correspondent will obtain a copy of the "Index to Engineering News for the years 1900 to 1904 Inclusive" and will turn to the heading "Concrete," he will find under the sub-head "Water in Concrete" the following references:

Discussion of wet and dry concrete. By H. W. Parkhurst. 1902, Vol. I—285.

Experiments with wet and dry concrete by Chic., Mil. & St. Paul Ry. By Irving Hitz, O. O. McReynolds, 1901, Vol. I—240, 322.

Notes of experience. By F. A. Mahan, 1902, Vol. II—51.

Proportion of water. Table showing effect of proportion of gaging water on cement mortar. By Clarence Coleman, 1903, Vol II.—187.

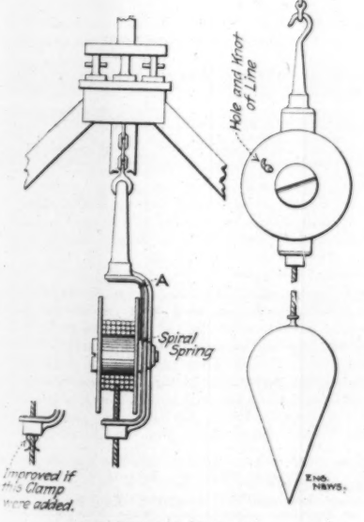
Relative strength of wet and dry concrete. By J. W. Sussex, E. R. Frink, 1903, Vol. II.—67, 100, 123.

Strength of concrete as affected by different percentages of water. By T. L. Doyle and E. R. Justice, 1903, Vol. II.—97, 100.

The articles thus referred to are ample to show that more than half a dozen years before Mr. Ney filed his patent application for what he termed a "rock-like substance," wet mixed concrete was in extended use and its advantages were a subject of public discussion by engineers. We hardly need say to our readers that more or less wet mixing of concrete has been done ever since the earliest days when concrete was used by engineers.—Ed.]

A Plumb-Bob Reel.

Sir: The writer has an appliance for holding plumb bobs on transits which avoids the various knots which you have given considerable space to describing recently. It is a simple brass reel holding 6 ft. of cord



A Plumb-Bob Reel.

and bobs weighing up to 16 oz. can be used with it. The disk edges are milled and the barrel contains a spiral spring. The plumb-line is wound on the barrel with the thumb and fingers, the friction of the spring impinging upon the bracket A, which holds the screw axis of the barrel, being sufficient to sustain the weight of the plumb bob. The lowering or raising is effected by a turn of the milled disks with the fingers.

The writer has used the above device and finds it superior to any of the knots or appliances he has known. An improvement, however, might be made if a flat spring clamp were added to the lower end of the bracket through which the string passes, this would put more friction on the bob line and improve the winding up process.

The appliance was invented by Mr. Paul C. Kammerer of the Pittsburg Instrument & Machine Co., Pittsburg, Pa., and is not patented. It sells for 75 cts.

James G. Haring.

Crafton, Pa., June 3, 1911.

Why is Europe in Advance of America in Pioneer Inventions?

Sir: Your question, "Why is Europe in advance of America in pioneer invention?" propounded in your issue of May 25 is, like its half brother, "What is the matter with our engineering schools?" difficult to answer because of the complicated and uncertain nature of the subject matter, but the following considerations may have some bearing:

In the beginning of any art, while the store of exact knowledge is as yet meager, quickness and resourcefulness are the important qualifications of the inventor; and given free opportunity and diffusion of general education, inventions which do not involve a large investment of time, money and previous training multiply. But a stage is reached sooner or later where further advance requires the application of scientific system in the collation and application of knowledge and then development is retarded, unless the means are forthcoming for attacking the more inaccessible problems involved, which often require, for their proper appreciation and solution, costly equipment and the mutual assistance of a large circle of co-workers, as well as life-long and specialized training.

While most American manufacturers are aware that the profits of engineering lie in pioneer work, not all of them as yet understand the proper utilization and management of research. The demand for research is not brisk over here and the schools have done little either to excite it or to turn out men properly qualified to fill the demand if such should arise. Possibly as an incident of rapid commercial expansion, engineering enterprises are generally controlled by business men, rather than by directing engineers, while the technician is a subordinate employee, who receives little encouragement or aid toward the initiation, planning or carrying out of sustained investigations.

In Europe, on the other hand, the situation is said to be quite otherwise, that is, the engineer or scientist frequently occupies a more independent position. I am told, for example, that Prof. Rateau, who has developed many lines of centrifugal machinery, including steam turbines, centrifugal pumps, air compressors, blowers, etc., licenses various concerns in France, Germany and elsewhere, that is, his rights are not assigned in toto to some corporation, as would probably happen in America.

Similarly the professors in the leading German technical schools, in addition to teaching, maintain large engineering offices, in which research and experimental development work is prosecuted on an extensive scale. The remuneration received from their inventions and for their engineering work enables these scientific engineers to maintain large staffs, while their connection with the laboratories and the other facilities of educational institutions naturally leads to the full utilization of the resources of scientific knowledge and methods.

This state of affairs naturally reacts upon the kind of instruction given in European technical schools, as contrasted with that presented here, where because of small salaries, and lack of opportunities for engaging in such outside work, the best men are either not retained or do not acquire the experience nor develop the methods which would enable them to train students properly in work of this kind.

As an illustration of this fact, the manager of a large concern producing machinery whose work requires broad training in theory, as well as systematic method on the part of the designing and engineering staff, recently stated to the writer that the graduates from the European intermediate schools employed in his works were generally found more ready and proficient in the use of mathematical and scientific methods than are the graduates of American technical schools of university grade, and, further, that no manufacturer of machinery of this class, even in this country, would think of engaging American graduates for high grade and advanced technical work.

The American graduate seems to have only an insecure and uncertain acquaintance with the fundamental concepts of mechanics, physics, mathematics, etc., and this applies even to plain arithmetic.

The foregoing may explain how it is that improvements in electric lamps, steam turbines, centrifugal pumps, water wheels, paper manufacture, textile manufacture, and the many branches of industrial chemistry, are largely imported.

Seemingly, we have a too self-sufficient trust in ingenuity and fail to take advantage of the resources of scientific method and knowledge. A further significant fact is that it is only in the European technical journals that there is a copious and continuous presentation and discussion of data and the theory relating to the scientific side of engineering. This applies particularly to Germany, where there are, for instance, two periodicals devoted solely to turbo machinery, eight to concrete and cement, two to scientific instruments, about twenty-five to theoretical and applied chemistry, etc., as well as numerous periodicals devoted to some special branch of technology or science, as journals of colloidal chemistry, the oxygen and nitrogen industry, etc.

There are also several journals professedly devoted to the subject of scientific and technical investigation and experiment, as well as some half dozen issued by testing laboratories. Even the English engineering periodicals closely follow the proceedings of physical, mathematical and chemical societies, often reprinting purely scientific papers entire, which, while they may have little immediate practical value, must act as a stimulus to thought and invention.

It may be suggested that we are too busy doing things, or that to a certain extent we still have some of the symptoms of a raw provincialism. In a new country, the easiest and most profitable things are naturally taken up first. However, this may lead to a solidification of crude methods, which may persist long after the plentifulness of capital would justify greater refinement and elaboration of methods, especially if competition by more advanced practice be eliminated as by a tariff wall. For the present it would seem that Europe is in the lead and well under way in the application of science to industry and we will need to improve or reform our institutions and habits before we can overtake her.

Geo. H. Gibson.

Tribune Building, New York City, June 24, 1911.

Concerning the Diesel Engine in the United States.

Sir: I read with a great deal of interest the paper presented before the Institution of Naval Architects, by J. T. Milton, on Diesel engines for sea-going vessels, as in your issue of May 25, and also your editorial referring to the same, entitled "Why Is Europe in Advance of America in Pioneer Inventions?"

I am well aware of the fact that in Europe and even in Siberia the Diesel engine is in successful operation under mechanically low-grade supervision; and for certain types of vessels, especially submarines, it is admirably fitted. It seems to me that Americans have been aware of the advantages of the Diesel engine and the reason for its not being adopted more widely in this country has been due to other causes than prejudices against complications in machinery, carelessness and extravagance, as you enumerate. I believe it is generally considered that the Diesel engine as originally produced in the United States, was not as efficiently made as the product in Europe today. Furthermore, the cost of the installation of these Diesel engines has always been reported as high, while the cost of operation and the expense of repairs has not justified their installation, even though the fuel efficiency was higher than in any other type of engine.

It is very probable that if a high-grade Diesel engine were manufactured in America and sold at a reasonable price, it would find an extensive market, especially in the larger horse powers; but to date, it seems as though any Diesel engine below 125 HP. could not be successfully constructed. With the low cost of crude oil and its distillates, together with the increasing cost of gasolene, there would be a large field for small engines working on a modified Diesel principle and ranging from 10 to 100 HP. To be commercially successful such an engine should not have to be equipped with an air compressor for atomising the fuel, but should have this action take place by mechanical means. In the Diesel engine the compression ranges from 500 to 600 lbs., but there is no good reason why this cannot be lowered to 200 lbs. with a slight decrease in efficiency. Of course, in this event the ignition would have to be by a hot bulb or some similar device.

I am informed that at least one manufacturer has realized the need of such an oil engine and is about to put on the market an engine ranging in horse powers up to 100 and using a compression about one-third of the Diesel. This is, as you know, considerably more than the average oil engine. The fuel will be atomized mechanically and there will be no need of an air compressor. It seems very probable that this engine will find a wide sale for small boats and for stationary use, especially as the first cost, maintenance and operation charges will be comparatively low. I believe that it might be called a modified type of Diesel engine in the sense that it approaches the high compression as obtained in the Diesel, which is the prime factor in the efficiency of that engine, but of course, the charge is not ignited by the temperature due to extreme compression, a hot bulb being used.

Yours very truly,

John S. Nichols.

Sharon, Mass., June 30, 1911.

The Duty of Electrical Engineers Toward the Public.*

By DUGALD C. JACKSON.†

Members of the American Institute of Electrical Engineers are pleased to refer to electrical engineering as a profession, and to the Institute itself as a professional society. When these statements arise from a ripe understanding that the word profession means more than a mere organized vocation for earning one's bread, it has a high and commendable meaning. The word "profession"

implies professed attainments in special knowledge, as distinguished from mere skill; a practical dealing with affairs, as distinguished from mere study or investigation; and an application of such knowledge to uses for others, as a vocation, as distinguished from its pursuit for one's own purposes.

This sets the professional man in a position which demands from him an attitude of service and of leadership. He must have a masterly knowledge, in addition to skill in a vocation. He must deal practically in the affairs or needs of men. His duties must be performed with a touch of disinterested spirit in addition to the vocational spirit of earning his livelihood. Such men have a duty to the public; and in the performance of that duty they must exert their influence on that thought and practice of the day which affects the welfare and progress of the nation. We as electrical engineers cannot escape that duty, in case we wish to maintain the professional character of our occupation.

It may be retorted that questions relating to the welfare and progress of the nation are matters of economics and sociology, and not of engineering. The affirmation contained in this retort I will admit, but the negation I deny.

The theory of modern economics is built up under the influences produced by the introduction of steam power, with its potent agencies comprised in the steam railroad, ocean navigation, and the use of steam power in industrial operations. These agencies are the creatures of engineers: Watt, Stephenson, Fulton, Ericsson, Boulton, Arkwright, Nasmyth, Bessemer, Siemens, Corliss, Holley and the other fathers of our modern industrial economic conditions were engineers. It would be folly to deny to the parents an interest in their offspring, and equal folly to assert that the further developments of economic theory are not largely dependent on those industrial changes which are continually produced by the inventive activities of the great body of engineers.

The engineers have precipitated these affairs on the world: these affairs are in a large measure the support of the engineering profession; and it is the duty of engineers to do their share in molding their various economic creatures so that the creatures may reach the greatest practicable usefulness to society. Theologians and physicians can practice their professions aloof from the ordinary affairs of the world, but the engineers associated with industrial events cannot do so.

It may again be retorted that the tenets which I am advocating will lead engineers out of a professional spirit and into "commercialism." This word strictly means the characteristics of business or commercial life, but custom has made it applicable to any undue predominence of commercial ideas in a nation or community, and it has thereby come to infer a willingness to establish the strife for money in a position of precedence over reason and righteousness.

It has been alleged that learning loses of its dignity by becoming fashionable. It has also been alleged that learning loses of its dignity by becoming useful. Of the latter, at least, experience has proved the contrary, happily for engineers who are proud of their profession, for engineering is necessarily an embodiment of the useful application of knowledge and learning.

Engineering, relating, as it does, to the application of the powers of nature to useful purposes, must necessarily bring its followers into intimate contact with commercial affairs in an age when, as in ours, the industries dominate commerce, and the abatement of war has reduced the importance of military engineering.

The tenets which I advocate do not tend to entangle the engineers in the depths of "commercialism" with which they may come in contact; but, on the contrary, those tenets propose that engineers should safeguard and nourish their professional spirit by assuming a part in public affairs in a spirit of disinterest, for the purpose of guiding the useful applications of natural forces to the greatest practicable service to society. A true engineer is a devoted follower after truth. He differs diametrically from the devotees of pure "commercialism," who are strictly opportunists. He also differs from pure idealists, who are often notable for refusing to accept any advance unless it wholly meets their personal ideals. The spirit of the engineer rejoices in obtaining any move toward the truth, but is always seeking farther advance.

The building up of a great industrial nation in an honorable state of civilization is subject to many hazards—an error may cause injury to the structure that takes years or even decades to eradicate. It is, therefore, desirable to go cautiously and utilize the mature reflection of straight-thinking men who will give their thought to the subject. The forward route is untested, and real progress can be made only by judiciously combining teachings from the records of yesterday with experience of to-day to make a working theory for to-morrow. Theory, as the word is used by engineers, means a working hypothesis founded on all known facts and experience, which may be used to guide progress beyond the margin of past experience. Every successful, progressive man is a constant user of theory in this proper sense of the term. Every progressive step is made according to a theory of the man responsible for the move. Theory is not antagonistic to practice but is founded on experience and is a guide to progress. Custom should be followed only when it has reason to support it.

The engineers have a special duty, as professional men who are trained and experienced in straight thinking, to use their influence for the establishment and support of right and reason in the dealings between the public and the public service corporations. The problems surrounding the public service companies in American cities, and their relations to the citizens, should receive particular attention by members of our Institute, for those problems and those relations have been largely brought to their present importance and prominence through the activities of electrical engineers.

The public service corporations are the natural outcome of the demand of the civilized world for efficient and rapid transportation and intercommunication, and the concurrent need as communities become immersed in peaceful industrial pursuits for ample and conveniently provided supplies of water, gas and electric power. They compose a comparatively new and mighty force in the social organism and the organism must be adapted to efficiently utilize this force, but the force must be prevented from dominating or warping the organism.

There is no danger of the public service corporations becoming despots as some people seem to fear, provided they are put under proper restraints, but society cannot afford to make restraints which of themselves are unnecessary or unfair. These corporations serve a beneficial end in our life, and their rights are as well founded and should be as well secured and held sacred as the rights of any citizens who are individually or collectively bent on any proper business pursuits.

Any fair-minded man of extended business experience who will study with unbiased intention the details of public ownership and public trading in the venerable and stable cities and states of continental Europe must be impressed with the reality that our inexpert and shifting governmental bodies are wholly unadapted to cope with such responsibilities, or to make an economic success equal on the average to that now accomplished by the privately managed service companies, whether the measure of success be taken on the basis of service provided for a unit of payment or on any other reasonable basis of comparison.

The public, misled or annoyed by the reluctance of some honest but overcautious managements to make frank public statements of financial results and present convincing statistics of operation, enraged by the acts of a few adventurers who from time to time have secured a speculative hold in the public service field, and enticed by the arguments of individuals with ulterior motives, are likely to follow the radical leadership of demagogues or of honest but false empirics.

This is a danger which seriously exists in states where no public supervision of the service companies is provided, and also in a lesser degree in states where such supervision has been established. The danger must be rolled back by the exertions of fair-minded and right-thinking men. A serious menace to the welfare of the nation would be caused if unfair dealing toward the public service companies were established as a policy. A scrupulously frank and honest dealing with the public by the companies should be insisted on, but the public must be taught the importance of dealing on its part with an equally scrupulous fairness and a well-balanced generosity.

It is here that I say lies a duty of electrical engineers to the public. It is to give of their time and brain to convincingly establish the facts which the public do not understand in regard to the business of the public service companies, to indicate the means for rightly treating these new influences which we and our fellow engineers have been creating by our works, and to aid in establishing measures which will favor and sustain mutual confidence and fair dealing between them and the public.

*Abstract of the presidential address delivered at the annual convention of the American Institute of Electrical Engineers, at Chicago, June 27, 1911.

†President, American Institute of Electrical Engineers; and Professor of Electrical Engineering, Massachusetts Institute of Technology, Boston, Mass.

Destruction of Cement Mortars and Concrete Through Expansion and Contraction.

By ALFRED H. WHITE.[2]

The change in volume of concrete due to temperature change has been determined with considerable accuracy to be for unit length 0.0000055 or 0.00055% per degree[3] Fahrenheit. There are, however, other changes due to the chemical processes of setting and hardening which are barely mentioned in even the more important treatises and other variations due to the wetting and drying of the concrete whose very existence is practically unknown. It is with these two latter classes of changes that this paper will deal.

REVIEW OF LITERATURE.

The literature of the subject is brief.

Quantitative measurements of the change of volume of cements while hardening commence with the classic experiments of Bauschinger[4] who in 1879 reported on the change in volume of eight different cements made into small cubes of neat cement and 1:3 and 1:5 mortar. One set of cubes was kept in water and one in air and the changes in length of one side observed for 16 weeks. The most important study of the subject was made by Schumann,[5] who, in 1881 and 1889, reported to the German Association of Portland Cement Manufacturers the result of expansion measurements made on blocks not only of neat cement and cement mortar but also on blocks of building stone. Gary[6] in 1889 reported from the Royal Mechanical Experiment Station at Gross Lichterfelde the results of the tests on ten Portland cements carried out jointly by the Experiment Station and a committee of the Association of German Portland Cement manufacturers. The tests included measurements of expansion bars of neat cement and of 1:3 mortar placed in water. No tests were made of bars in air. The average results of the expansion tests at the experiment station are given in Table I.

A few results by Tomëi[7] were quoted by Gary before the International Engineering Congress in 1893.

Campbell and White[8] in 1906 presented a study of 56 expansion bars of neat cement which had been under observation for five years. A number of these were pathological specimens of unsound cement containing free lime and magnesia, but their experiments showed as much as 0.19% expansion with sound neat cements kept in water for five years and a shrinkage as high as 0.39% with bars of sound neat cement kept in air. A reliable and inexpensive micrometer and a satisfactory method of inserting the glass plates in the expansion bars were described in this paper. These improvements obviate the difficulties found by some of the earlier German investigators in getting concordant results. Table I presents the condensed data of the investigators mentioned.

The foregoing tests were all made on small bars without metal reinforcement. So far as the author has been able to discover, only two investigators have ever attempted to study the most important subject of volume changes in reinforced concrete. Considere[9] in 1899 reported the behavior of small bars of neat cement and of mortar made with 600 Kg. cement to each cubic meter of sand. The prisms were 60 × 25 × 600 mm. Half of them were reinforced each with a round steel bar 10.2 mm. in diameter. The measurements extended over a period of 63 days and at the close of the period showed the following changes reported as mm. per 100 mm.

	In water.	In air.
Neat cement not reinforced	+0.079	−0.132
Neat cement reinforced	+0.022	−0.023
Mortar not reinforced	+0.028	−0.050
Mortar reinforced	+0.006	−0.010

Emerson[10] in 1904 studied the change in length of the reinforcement. Bars of neat cement and of concrete of various proportions were made 8 × 8 ins. × 3 ft., each bar carrying a steel rod ½-in. square and 3 ft. 6 ins. long. The progressive changes in the length of the rods were measured for 3 months and the resulting stresses in the steel calculated from Hooke's law. The final measurements on bars kept constantly in water showed a tension stress on the steel amounting to about 8,000 lbs. per sq. in. when bedded in neat cement and decreasing to a little over 1,000 lbs. in 1:3:6 concrete. On bars kept constantly in air the steel was shown to be under a compression stress which was usually greater than the tension stress developed in bars kept under water. When bars taken from water were placed in

[1]Paper read before Annual Meeting of the American Society for Testing Materials, Atlantic City, N. J., June 27-July 1, 1911.

[2]Junior Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich.

[3]Pence Engineering News, 46, 380 (1901).

[4]Bauschinger. Mitth. Mech. Tech. Lab. d. tech. Hochschule in München 8th Heft 1879.

[5]Schumann. Tonindustrie Zeit. 5, 184 (1881) and 13, 435 (1889).

[6]Gary. Mitth. a. d. kgl. tech. Versuchsanstalt zu Berlin 1899. Ergänzungsheft 1.

[7]Tomëi. Trans. Am. Soc. C. E. 30, 16 (1893).

[8]Campbell and White. Jour. Am. Chem. Soc. 28, 1273 (1906).

[9]Considere. Competes rendus 129, 467 (1899).

[10]Emerson. Engineering News, 51, 222 (1904).

TABLE I.—CHANGE IN VOLUME OF BARS OF NEAT CEMENT AND CEMENT MORTAR.

	Neat Cement.	1:3 Sand.	1:5 Sand.	Duration.
Expansion after lying continuously in water:				
Bauschinger Av. of 8	+0.046%	+0.009%	+0.001%	16 weeks
Schumann Av. of 7	+0.150	+0.028	....	1 year
	....	+0.029	....	2 years
	....	+0.027	....	5 years
Tonnel Av. of 8	+0.025	+0.027	....	90 days
Considère	+0.079	+0.028	....	63 days
Gary Av. of 10	+0.063	+0.008	....	1 month
	+0.078	+0.013	....	3 months
	+0.094	+0.012	....	1 year
	+0.092	+0.020	....	2 years
Campbell and White	+0.190	....	....	5 years
Contraction after lying continuously in air:				
Bauschinger Av. of 8	—0.214%	—0.132%	—0.124%	16 weeks
Schumann Av. of 4	....	—0.042	....	1 week in water then 3 weeks in air.
Tonnel Av. of 8	—0.201	—0.094	....	90 days
Considère	—0.132	—0.050	....	63 days
Campbell and White	—0.390	....	....	5 years

TABLE II.—CHANGES IN VOLUME OF BRICK AND STONE WHEN ALTERNATELY WET AND DRIED, ACCORDING TO SCHUMANN.

	2 weeks in water.	2 weeks in air.
Brick, light burned red	+0.016%	—0.015%
Brick, hard burned white	+0.010	—0.009
Brick, hard burned white	+0.019	—0.010
Brick, vary hard burned black	+0.006	—0.008
Sandstone, red fine grained	+0.006	—0.018
Sandstone, red coarse	+0.016	—0.023
Sandstone, green fine grained	+0.050	—0.050
Sandstone, red fine grained	+0.050	—0.050
Sandstone, red very fine grained	+0.206	—0.178
Limestone, white	+0.004	—0.008
Limestone, Lothringer Lias	+0.007	—0.008
Limestone, Chalk	+0.011	—0.009
Limestone, dense containing clay	+0.026	—0.026
Granite	+0.006	—0.013
Basalt, a	+0.041	—0.050
Basalt, b	+0.026	—0.027
Basalt, c	+0.048	—0.050
Basalt, d	+0.023	—0.057

air the stresses in the steel changed from tension to compression as the bars dried. No direct measurements were made on the volume changes in the concrete.

Only one experiment seems to have been made on a really large scale. Binnie[11] constructed a block of 1:4 granite concrete 100 ft. in length and 1 ft. square built on rollers so as to be free to expand. He dismisses the subject of effect of moisture with the unsatisfactory

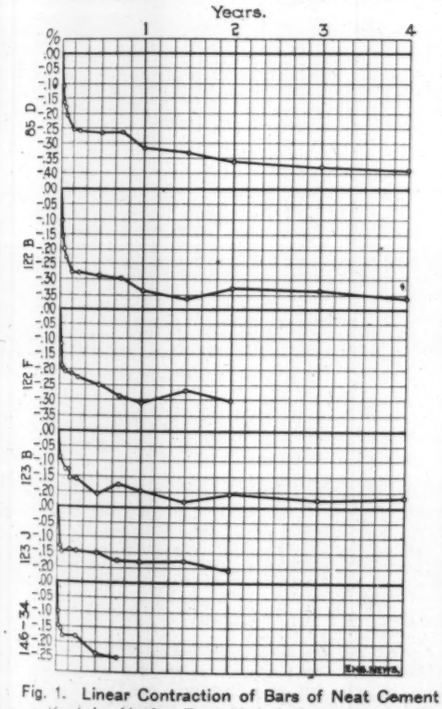


Fig. 1. Linear Contraction of Bars of Neat Cement Kept in Air for Four Years, Expressed in Per Cent.

statement that in wet weather the expansion due to moisture was often as much as that due to summer heat.

The experiments of the investigators cited above agree in showing that neat cements hardening under water expand at a decreasing rate for several years, that neat cements hardening in the air contract in a similar manner and that cement-sand mortars change in the same direction as the neat cements but to a lesser extent.

The effect of alternately wetting and drying concretes is given qualitatively from the experiments of Emerson.

[11] Binnie. Proc. Inst. C. E. 160, 21 (1905).

Quantitative measurements are entirely lacking. It is worthy of comment that although several investigators have reported on the behavior of bars in water for periods of several years, none have reported on the behavior of bars kept in air for a period of more than four months, with the single exception of Campbell and White, who studied one commercial cement during four years.

This curious laxness in the study of the properties of Portland cement which, next to steel, is the world's most important building material, arises probably from two causes. In the early days of the Portland cement industry the material was used almost entirely for structures such as foundations where it was kept constantly damp. It justified itself under these conditions and the assurance with which it was used in damp places transferred itself unthinkingly to conditions where cement is less stable. The other reason for the oversight is probably to be found in the fact that few engineers who use cement have had the chemical training which would enable them to study the complex phenomena involved in these changes.

The following paragraphs show especially the effect of alternately wetting and drying bars of neat cement and sand mortar. There are also included the behavior of various bars of neat cement kept continuously in water and in air. These are included not only because more data on the subject is desirable but because the Portland cement now being used is a different material from that tested by the European investigators, who undoubtedly worked with cements made in the old vertical kilns. The modern American cement made in rotary kilns differs from the older not only in method of manufacture but also in chemical composition and is worthy of separate study.

UNIVERSITY OF MICHIGAN TESTS.

EXPERIMENTAL METHOD.—The method of making and measuring the expansion bars was that of Campbell and White. The dimensions of the bars are approximately 4 × 1 × 1 in. and they contain beveled glass plates cast into the end to ensure a smooth surface for the micrometric measurements. The Portland cements used were all commercial samples which passed successfully the standard tests for soundness. Standard methods were used in proportioning the water and in mixing. The initial measurement was made after the bad had stood 24 hours in the damp box.

Campbell's perfected micrometer is described and illustrated in the paper referred to. It is possible to make three successive readings with it with a maximum error of about 0.005 mm. Since the bars, after the thickness of the glass plates embedded in the end is deducted, are almost exactly 100 mm. long, each 0.001 mm. equals 0.001%. In making measurements three successive readings are taken and the mean recorded. The bars and micrometer are kept continuously in a room surrounded on all sides by other rooms in a building whose temperature in winter is controlled by automatic thermostats. During cold weather the temperature of the room will not vary more than two or three degrees from 70° F. In summer the temperature may rise to 80° F. Since the difference in the coefficients of expansion of the cast iron yoke of the micrometer and of concrete is only 0.0000005 temperature variation in the room introduces merely a negligible error.

Contraction of Neat Cement in Air.

The curves of Fig. 1 show the linear shrinkage of bars of neat cement kept constantly in air. Four different brands of commercial cement all passing standard specifications for constancy of volume are represented. The volume of these bars varies with the humidity of the air but on the whole the shrinkage of all the bars is reasonably uniform and averages:

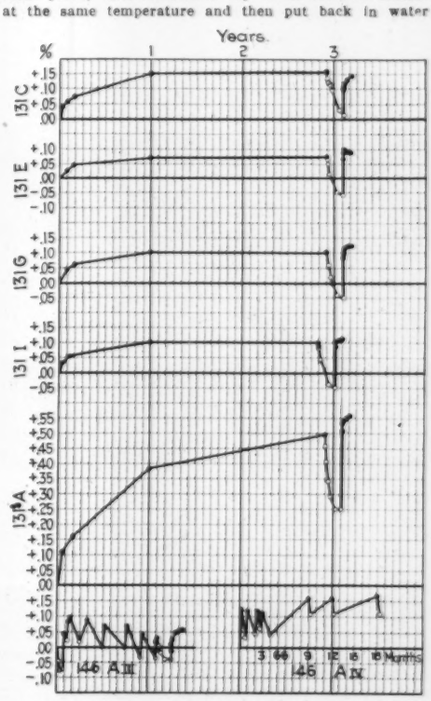
7 day (Av. of 6)	—0.109%
28 day (Av. of 6)	—0.190
6 months (Av. of 6)	—0.238
1 year (Av. of 5)	—0.270
2 years (Av of 5)	—0.289
4 years (Av. of 3)	—0.322

It is evident that one-third of the shrinkage comes in the first week, more than half of it in the first month and almost all of it in the first year. A shrinkage of 0.322% amounts to nearly 4 ins. on 100 ft. and indicates clearly why it is not possible to use neat cement for interior floors and wall finishes. The change in volume of cement and sand mortars will be treated later.

It is often held that the use of fresh cement is responsible for cracks in finished work. It is therefore of particular interest to note that freshness cannot be held responsible for the changes shown here. Bar 85 D was made from cement which had been stored in our laboratory for six months before use. Bar 122 B was made from an inspector's sample of commercial cement when it was received at the laboratory and 122 F was made after it had stood in an open bottle in the laboratory for two years and five months. Bar 123B was made from a commercial cement the day after it had been ground at the mill and 123 J after it had been aged two years and six months. In neither case can any effect of ageing be noticed. The shrinkage at the end of two years is practically identical in the aged and fresh cement.

Changes in Volume of Bars of Neat Cement in Water and Alternately Wet and Dry.

The first four curves of Plate II show the changes in four bars of neat Portland cement when kept under water at approximately constant temperature for almost three years, then allowed to dry in air for two months at the same temperature and then put back in water



Closed circles indicate measurements of bars taken from water.
Open circles indicate measurements of bars lying in air.

Fig. 2. Linear Expansion and Contraction of Bars of Neat Cement When Alternately Wet and Dry, Expressed in Per Cent.

again. The mills represented are: 131 C, one of the largest Lehigh Valley mills; 131 E, a small Michigan mill of good reputation working wet process with marl and clay; 131 G, one of the large mills using slag and limestone; 131 I, another Michigan mill using wet process. The fifth curve of Fig. 2 (131 A) shows the changes in a bar of natural rock cement from one of the leading mills of the country. The last curve (146 A3 and A4) show the variations in two bars of cement from still a different Michigan mill.

The behavior of the first four Portlands kept constantly in water for three years is quite in accord with the results obtained by European investigators. The linear expansion at the end of the first year amounts to from 0.07% to 0.15% and the expansion after the first year is very slight. The high expansion of the natural rock cement, 0.49% after three years in water is worthy of note as being quadruple that of the average of the Portlands.

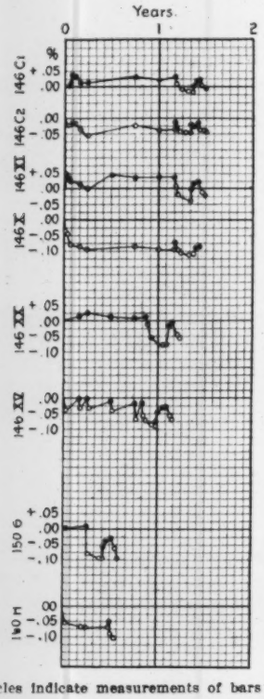
Attention is especially directed to the contraction in these bars after they were removed from the water and allowed to dry in the air at room temperature. The change in volume was slow and had not entirely ceased after 65 days when the test was terminated. The values were, however, remarkably concordant, the largest contraction of the four Portlands being 0.15% and the smallest 0.13%. The bars not only shrank to their ini-

tial volume but three of the four contracted further. When the bars thus air-dried were again placed in water the expansion was rapid. In one day they recovered 90% of all the length which they had lost in 65 days air-drying and in the course of the next month they slowly expanded further until three of the four were longer than they had ever been. The exception, Bar 131 C, changes very slowly and it appears from the curve that it had not reached equilibrium either on drying or wetting.

From the standpoint of structural stability it is rather disquieting to learn that these cements which had remained in water without any measureable change in volume from their first to their third year shrank 1.7 ins. on 100 ft., when they were dried in air and in 24 hours when again brought in contact with water expanded 1.5 ins. and within a month had expanded 1.8 ins. calculated on an initial 100-ft. measurement. The question of the ultimate limit to these changes is discussed later.

The natural rock cement 131 A changed similarly but in a more marked degree. Its linear contraction on drying for 60 days amounted to 0.24% and its expansion after subsequent immersion for 24 hours in water to 0.25%. The total expansion after 30 days in water was 0.30%.

A more complete illustration of the magnitude and regularity of the changes in volume as the cement passes from the wet to the dry state is shown by the last curves of Fig. 2, Bars 146 A3 and A4. These bars



Closed circles indicate measurements of bars taken from water.
Open circles indicate measurements of bars lying in air.

Fig. 3. Linear Expansion and Contraction of Bars of 1.3 Cement Mortar When Alternately Wet and Dry, Expressed in Per Cent.

have during their 18 months' existence been systematically alternated in air and water. The points make a fairly regular sawtooth curve which would probably have been more regular had a longer time been allowed for equilibrium in the early portion of the test. The last change of 146 A3, which was the most carefully watched, shows a variation from —0.038 to +0.038, a total change of 0.076% as it passed from the wet to the dry state for the seventh time. The behavior of these companion bars 146 A3 and A4 is treated more fully in the discussion of the behavior of sidewalks.

Change in Volume of 1:3 Sand Mortars as Alternately Wet and Dry.

Fig. 3 shows the changes in length of eight bars of Portland cement mortar mixed in the proportion of one part by weight of cement to three standard Ottawa sand. The curves are quite like those of the neat cement but the changes are on a smaller scale. The bars kept continuously in water expand within the first few weeks as much as 0.05% but decrease after that and usually expand again later to a figure that is no greater than 0.05%. Bars kept continuously in air show greater volume changes than those kept in water, the contraction after three months averaging about 0.08% and running as high as 0.10%. When the bars change from the dry to the wet state and vice versa the change in length is about 0.06%.

One of the best known commercial waterproofing compounds, used in accordance with the manufacturer's directions, was incorporated with the four middle bars of Fig. 3 (146 X, XI, XV, XX) in the hope that the value of such compounds might be demonstrated. There is no evidence of favorable effect, the change between the wet and dry states being full as large and apparently as prompt as in the bars not waterproofed.

Variations in Volume of Compound Bars.

In order to get a direct comparison between bars of neat cement and those made with sand under identical conditions, compound bars were made by casting a bar of neat cement integrally on a freshly formed bar of the same dimensions made by taking one of cement to three of sand. Four of these bars were made from the same lot of cement at approximately the same time. Their variations in volume are reported graphically in Fig. 4, the initial measurement of each being plotted as zero.

Compound bar 146 VII was kept continuously in water for 14 months. Both portions expanded but at unequal rates so that at the end of this period the neat bar was 0.03% longer than the one containing sand. On drying in air both shrank, but the mortar bar contracted the more rapidly so that at the end of a week the neat bar was 0.072% longer than the other. As the mortar bar reached equilibrium the neat bar caught up with it and even passed it so that at the end of two months it was the shorter by 0.012%. On placing in water both shot up rapidly, the sand 0.050% in 24 hours and the neat 0.086%. The neat bar kept growing until as was the case with the four neat cements previously noted, it overtopped any previous record and at the end of a month was 0.075% longer than its companion, whereas after 14 months previous immersion in water it had only been 0.038% the longer.

Compound bars 146 II and 146 VI were made to test the effect of fineness of sand. The mortar bar of 146 II was made with Standard Ottawa sand while 146 VI contained river sand from which everything coarser than 40 mesh had been sifted. Both bars were kept in air for over a year and then immersed in water. No marked effect of the difference in sand can be noted. The contraction of the bar with the fine sand is rather less than that with the standard sand but the difference is not definite enough to be certain. The neat cement portions of the bars behaved alike and similarly to the others noted, contracting over 0.20% in one year. At the end of the year the neat cement bar 146 II was 0.147% shorter than its companion mortar bar and the neat bar 146 VI was 0.150% shorter than its companion. On placing in water there was the usual sharp expansion followed by a contraction as the bars were again dried in air and another expansion as they were placed in water, and so on.

Compound bar 146 I was changed every week during its first few weeks and shows the usual sharp alterations with no sign of decrease in intensity with age.

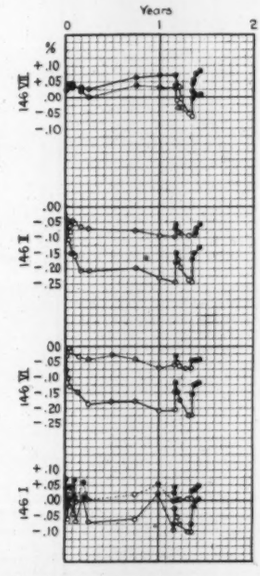
Illustration From Actual Practice.

It may be urged that the foregoing tests were all made on small bars manufactured in the laboratory and that such large values might not be obtained in actual practice. To meet this objection and also to make the case stronger the results shown in Fig. 5 are introduced. The scale in this plate is purposely changed in order that the steady nature of the changes in volume may be shown by the daily measurements. The ordinates remain the same but the abscissas are magnified 30 times, each horizontal unit representing a day.

Bar 156 A is made from a part of the cement sidewalk on the north side of the campus of the University of Michigan. It was laid in 1890 from imported German cement by the University workmen who were paid by the day and under no temptation to slight the work or skimp cement. Most of the slabs of this walk are now warped slightly so that shallow puddles of water stand in them after a rain and even after 20 years the expansion is still occasionally causing adjacent blocks to heave and form an inverted V. The top layer is split from the bottom in many places and it was from one of these pieces of the top coat that bar 156 A was sawed. An examination of its lower surface shows that the split was not due to faulty bonding, for the break has occurred not at the exact junction of the top coat and base, but just below the upper surface of the base. The top coat carries with it a thin layer of the base. This bar became dampened in the sawing process and was therefore put into water and allowed to become saturated and fully expanded before the measurement recorded as the initial was made. It will be noted that it then contracted slowly for 14 days in the air, the total shrinkage being 0.05% and that on putting it into water it expanded to practically its initial volume in four days. When removed from water it contracted again as before.

Another instance to which attention is called is bar 156 E cut from a piece of cement stucco which came loose from a brick porch after only two years service. The stucco is well mixed, has a good ring and is rd. The brand of cement used and the proportions are n- known but it is certainly a rich mixture, probab as high as 1:1. The stucco in coming off did not spl off from the brick but in almost all instances carr a thin skin of the brick adhering to it showing tha he fault did not lie in failure to bond the two mat ls together. The behavior of a bar sawed from this s co is shown in the curves 156 E. It was sawed to s pe without moistening and when placed in water fo 24 hours it expanded 0.07% and reached 0.08% after ur days in water. On drying in air it slowly return to its original volume. It is not to be wondered at at a stucco which expands practically 1 in. on 10 ft. whenever it gets thoroughly wet, should fail.

Another instance of change of volume in ma ial which has been in use many years is afforded by he study of a section of cement sidewalk which was t ken up in good condition after 20 years' service. From his was sawed one bar approximately 1 × 2 × 4 ins. on- sisting of the top coat 1 × ¾ × 4 ins. on a section of he bottom portion 1 × 1¼ × 4 ins. This bar (156 F) is therefore similar in many ways to the compound bars of neat cement and 1:3 mixture before referred to. This bar showed the usual expansion of both layers in water and the contraction in air which was expected. When placed in water the bottom layer expanded prac- tically its whole amount (0.033%) in 15 mins. while the richer top layer expanded in the same time only 0.010%. At the end of 24 hours the top portion had expanded 0.028%, and after three days had become prac- tically constant with almost the identical expansion



Full lines denote neat cement.
Dotted lines denote 1.3 mortar.
Closed circles indicate measurements of bars taken from water.
Open circles indicate measurements of bars lying in air.

Fig. 4. Linear Expansion and Contraction of Compound Bars of Neat Cement and 1.3 Sand Mortar When Alternately Wet and Dried, Expressed in Per Cent.

0.035% which the bottom showed. This is interesting partly because of the evidence of alternate bending stress in the concrete due to the more rapid expansion of the lower layer and partly because of the ultimate agreement in expansion of the top and bottom portion. Note that this cement sidewalk was in good condition after 20 years' service. It is possible that its satisfactory condition is due to this agreement in coefficient of expansion of the two layers.

Another bar was sawed from the same piece of this sidewalk immediately adjacent to the first one but instead of being left as a compound bar it was again sawed at the line of demarcation between the top and bottom coats, so that the top portion (Bar 156 C) was separated from the bottom (Bar 156 D). These two bars were then alternately wet and dried as the others had been to determine whether in the compound bar the change in volume of one portion had been influenced by the other. This has apparently not been the case in this bar for as shown by the curve the two portions C and D expand and contract to about the same extent and at the same rate as in the compound bar B.

Summary of Experimental Data.

In the foregoing pages there has been presented data on the sadly neglected subject of expansion and contraction of hydraulic cements as they age in water and

in air and as they are alternately wet and dry. It should be emphasized, however, that the number of experiments is entirely inadequate to make it proper to quote them as average results. They are to be regarded merely as illustrations of how some acceptable commercial cements have behaved. It is, however, permissible to summarize the extremes to show the range of fluctuation.

Neat cement bars hardening under water
- After 1 year, expansion 0.07 to 0.15%; 1 year to 4 years, almost no change.
- On drying after 3 years in water contraction 0.13—0.15%.
- On wetting again expansion of 0.13—0.17%.

Neat cement bars hardening in air.
- Contraction after 3 months..... 0.14—0.28%
- Contraction after 1 year..... 0.18—0.34%
- Slight increase to 4 years.

1 cement: 3 sand bars
- Hardening under water—expansion 0.01—0.05%, the greatest changes being in the first few weeks.
- Hardening in air—contraction 0.06—0.09%, most of the contraction being in the first three months.
- On wetting and drying, expansion 0.04—0.09% on wetting, and contraction within same limits on drying.

Compound bars made of one layer of neat cement on a layer of 1:3 sand expand and contract together but at different rates and to different degrees. The differential expansion varies from 0.00—0.15%.

The one natural rock cement tested showed twice as much variation in volume as Portland.

These variations in volume with change of moisture content do not disappear with lapse of years for changes of 0.05 and 0.06% have been observed in bars cut from sidewalks which have been laid down 20 years.

Changes In Monolithic Cement and Concrete.

These changes noted above may seem small but when converted into other figures their real seriousness becomes apparent. The following hypothetical illustrations are presented to show the magnitude of the possible stresses.

Imagine a wall of neat Portland cement 100 ft. long anchored at each end to absolutely immovable supports. Let it be kept under water for three years. At the end of that time it would, had it been free, have expanded 0.1% or 1.2 ins. Since it is supposedly not free to expand the compression will be 0.1% and the compression stress on an assumed basis of a 5,000,000 lbs. modulus of elasticity will be 5,000 lbs per sq. in. Perhaps the cement could withstand this pressure.

Imagine now that this cement wall becomes dry. It should contract 1.7 ins., but since it is not free there will be developed a tensile stress of 7,500 lbs. per sq. in., which is several times more than it can stand. The wall would have to crack.

Suppose this neat cement wall had been originally allowed to harden in the open air. After two years it would if free have contracted 0.25%, but since it is anchored at the ends there will be (assuming the same modulus) a tensile stress of 12,000 lbs. per sq. in. Is it not evident why neat cement is not used in practice?

If the above wall had been built of concrete with the same volume changes as the 1:3 sand bars and as the old sidewalks whose measurements are given above, its change in length between the wet and dry states would probably have amounted to 0.05% which with a modulus of elasticity of 2,500,000 lbs. per sq. in. corresponds to a stress of 1,250 lbs. per sq. in. The concrete could withstand this in compression but not in tension. Not even our best steel will stand indefinitely repeated alternate bending stresses which stress it nearly to its elastic limit. Why should we wonder then if a rich cement mixture should ultimately crack when exposed to the stress resulting from a volume change of 0.05% every time it is exposed to rain or sunshine.

There is no experimental evidence which shows the changes in volume of leaner concrete. It is evident that the properties of the sand and rock become of increasing importance as their percentage increases. The tests by Schumann on volume changes in building stones, quoted at the commencement of this paper, show small values for limestone but variable values for sandstones, the upper figures being almost as high as those quoted for neat cement. Whatever the values might be for crushed stone as used in concrete it is hardly conceivable that gravels and sands which have withstood the action of the weather for centuries without disintegration can change their volume much when wet and dried. It seems probable that in gravel concrete the volume changes decrease as the cement decreases until a certain lower limit is reached where the change in volume is purely a capillary phenomenon.

If this line of reasoning is correct those concrete structures should be most stable when exposed to the weather where there is just sufficient cement to give strength but not enough to cause excessive volume changes. Practical experience apparently confirms this view.

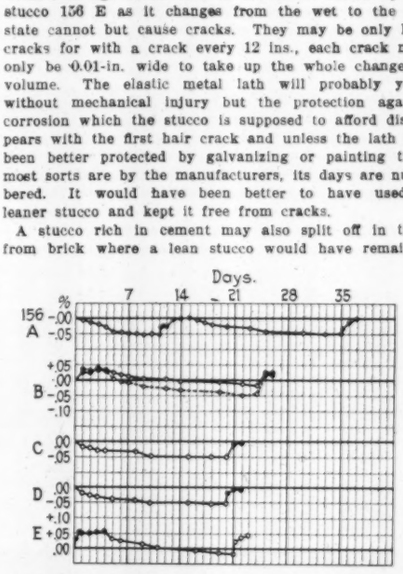
Stucco.

There are many instances where stucco has remained perfect even when exposed to the weather for half a century. There are probably more instances, especially in recent years, where stucco has failed miserably in five years. The excellence of old stucco is sometimes laid to the natural rock cement with which most of it was made. It is not safe to deny this on the evidence of a single experiment, yet attention may be drawn again to the one natural rock cement which has been tested in our laboratory, whose volume changes were in every way much greater than those of Portland.

Is it not more probable that the old stucco has survived because of its lower proportion of cement? When it was simply a question of providing a rough brick or stone wall, entirely durable in itself, with a smooth surface, and when in addition hydraulic cement was expensive, it was natural to use a mortar containing just enough cement to adhere to the wall. With the introduction of metal lath as the support for stucco, and the necessity of protecting the metal from corrosion, coincident with the drop in price of Portland cement came the use of richer stuccos.

The step was apparently an unfortunate one for a volume change of an inch in 100 ft. as shown by the stucco 156 E as it changes from the wet to the dry state cannot but cause cracks. They may be only hair cracks for with a crack every 12 ins., each crack need only be 0.01-in. wide to take up the whole change in volume. The elastic metal lath will probably yield without mechanical injury but the protection against corrosion which the stucco is supposed to afford disappears with the first hair crack and unless the lath has been better protected by galvanizing or painting than most sorts are by the manufacturers, its days are numbered. It would have been better to have used a leaner stucco and kept it free from cracks.

A stucco rich in cement may also split off in time from brick where a lean stucco would have remained



Closed circles indicate measurements of bars taken from water.
Open circles indicate measurements of bars lying in air.

Fig. 5. Linear Expansion and Contraction of Bars Cut from Stuccos and Sidewalks When Alternately Wet and Dried, Expressed in Per Cent.

good. The change in volume of brick when wet and dry is according to Schuman less than 0.02%. If the change in the stucco is 0.08% there is opportunity for a stress corresponding to a volume change of 0.06% which might be 1,500 lbs. per sq. in. The fact that the stucco has not split off in one year or two years does not mean that it may not split off in five or ten.

Interior Floors.

The question of reinforced concrete is discussed in a later paragraph. Here only the changes in the concrete itself will be considered. The usual practice will be assumed in which there is a base of rather lean concrete covered with a wearing coat of mortar sometimes as rich as 1:1.

The first case assumed will be that of a cellar floor where the base is tamped down and the top coat at once put on, giving the best conditions for bonding. The whole mass gradually dries out and shrinks, but the top coat because of its high content of cement shrinks more so that the conditions will be somewhat those represented by curves 142 II and VI of Fig. 4. The top coat will tend to split from the base but since a cellar is always relatively damp there will probably be little trouble.

The situation is not so favorable when a top coat is to be laid on an upper floor of a concrete building. The main portion of the floor has been poured for possibly three months and has already completed most of its shrinkage. Its surface is also probably dirty so that the freshly poured mortar will not readily unite with it. Both of these circumstances are unfavorable. The fact that the main portion of the floor has already dried out and shrunk causes an even greater differential shrinkage of the top coat. The advice is usually given to wet the floor thoroughly before pouring the top coat. It would be better to keep it wet for 24 hours beforehand in order to give it an opportunity to expand to somewhere near its initial volume.

It is not surprising if under these circumstances the top splits off the base, shrinkage cracks appear, and the individual slabs curl up somewhat at the edges in the effort to relieve the shrinkage strains. In case electric conduits, etc., are bedded in the top coat their course will be indicated by shrinkage cracks following the lines of weakness which they cause. Since these floors remain continually dry, conditions will become constant after a few months, and there will be little further change.

Sidewalks and Pavements.

The chief factor which influences the behavior of sidewalks and pavements is the weather. The influence of temperature is well known and will not be dwelt on. A sidewalk usually consists of a base of rather lean concrete covered with a wearing coat of cement mortar which may be as rich as 1:1 and is not usually poorer than 1:2. The walk is cut into blocks and is sometimes provided with expansion joints.

As the walk dries out the top coat shrinks more than the bottom, as shown in the experimental study of compound bars. The effect can often be seen in sidewalks where the contraction has dished the entire slab so that shallow puddles of water stand in them after a rain. As the walk is wet by the rain the top expands more than the base. The alternate bending stresses thus developed all too often show themselves after a few years when the top coat splits off the base.

The necessity of expansion joints is now well recognized, although they are put in principally to take care of expansion due to changes of temperature. The experiments presented in this paper on both neat and sand briquettes indicate that the expansion of cements kept wet ceases at the end of the year, and that the total expansion does not amount to over 0.1%. This would require a ¼-in. expansion joint every 20 ft. In addition there must be the joints to care for the expansion due to summer heat, which for a rise of 100° F. is 0.05% about half what may be expected from moisture. To take care of the volume changes from both these causes a ¼-in. expansion joint every 10 ft. should be adequate although it does not include much margin of safety. In hot weather after a long rain these joints would be be almost closed. In dry or colder weather they would be open.

According to the experimental figures any evils due to expansion should make themselves evident during the first two years, but practice does not always bear out this assumption. Reference was made at the commencement of this article to the cement walk laid around the campus of the University of Michigan 20 years ago, which is still showing expansion and giving mute evidence of the pressure generated by occasionally thrusting up two adjacent slabs in an inverted V. This is not a phenomenon due to summer heat for it occurs usually in the spring. What is the cause which is still making this walk expand after 20 years?

An explanation may be suggested although it is not possible to prove it completely. It is well known that the glass of thermometers expands when heated and contracts when cooled, but not to its original length except after a long lapse of time. Thermometers which are used frequently at high temperatures keep growing longer. If they are laid away for a long period of time they shorten again and may even become shorter than when first calibrated. Metals behave similarly, so that it is not possible to utilize their expansion for making pyrometers which will not need frequent recalibration. The warping of the grate bars of fire boxes due to expansion is another illustration. It would be natural to expect by analogy that concrete would tend to a permanent expansion when it is kept wet longer and oftener than it is dry and that it would tend to become shorter under the opposite conditions. The experiments of this paper in general confirm this theory. Of the five bars of neat cement of Fig. 2 which had been kept under water for three years and were then dried out and reimmersed, all but one were longer after the reimmersion than they had been, and the one exception is apparently susceptible of explanation.

A more striking illustration is afforded by the two neat bars 146 A III and A IV which are shown at the bottom of Fig. 2. These bars were made on the same day from identical materials, but after the initial measurement A III was left in the air and A IV placed in water. They were then alternated between air and water, at first at the end of each week and afterwards at longer intervals. There is, however, a definite difference in the treatment of the two for with A III each cycle has consisted of a period in air of two or three months followed by an immersion in water of usually a week. It has therefore been dry most of its life and its mean length since the end of the first month has been steadily diminishing as the curve clearly shows. The companion bar A IV was subjected to the opposite treatment in that its long periods were in water and its short periods in air. Its mean length and also its length when wet has been steadily increasing for the 18 months of its existence although the rate of increase since the ninth month has been slow. At its last measurement it was slightly longer than another bar of the same cement which had been kept constantly in water but it will require a longer time to decide whether the increase is material.

This theory of the continued expansion of cement walks in a rather damp climate such as that of Michi-

gan is the only one which seems adequately to explain the compression ridges still occasionally developing in the 20-year-old walk on the campus of the University of Michigan which has been referred to before. If the theory is correct it would indicate that there would be more trouble with cement sidewalks and pavements in wet countries than in those which are reasonably dry, and that there is need of much wider expansion joints in damp climates.

Reinforced Concrete.

It is evident from the data presented here that concrete undergoes a notable shrinkage as it drys. If a concrete beam is formed rigidly fixed at both ends, as is practically the case in skeleton concrete construction, it is evident that on hardening it must be under an initial tensile stress due to contraction. Conditions will not be changed by the presence of steel reinforcement provided the ends are absolutely rigid. If, however, the ends of the beam yield at all and the concrete adheres to the steel the strains will be adjusted between the two. The steel will be in compression and the concrete in tension but to a lesser extent. In the review of the literature at the commencement of this paper attention was directed to the experimental work of Considère and to the experiments of Emerson, who found that even with mixtures as lean as those used in practice, compression stresses of 2,500 lbs. per sq. in. might be developed in the steel through the volume changes in the concrete of bars only 3 ft. long and not anchored at either end. The paucity of information on this subject should be emphasized. There is every probability that there are important stresses in all reinforced-concrete work due to volume changes in the concrete of which the designers have had no knowledge. These stresses may have been to blame for some of the collapses which have occurred in reinforced work and the small number of such collapses may be more a tribute to the value of the factor of safety than to scientific knowledge.

It is encouraging to note, however, that in buildings, where the beams remain dry, most of the contraction will have taken place at the end of the first three months and that from that point on the volume changes will be slight. Concrete floor beams are treacherous during the first few weeks not only because the concrete itself is new and weak but because of the tensile stresses developed.

There is danger that a rather slight load on a green beam may cause cracking if not total failure for it is entirely possible that the whole of the concrete is in tension and its tensile strength at that stage is very small. Several weeks should be allowed to elapse even in warm weather before the forms are taken off and the supports removed. Fortunately these tensile stresses seem to practically reach their maximum in three months, while the concrete gains in strength for a much longer period so that if a concrete building is successfully completed there does not seem to be a probability of future failure due to changes within the concrete.

Causes of Change of Volume.

There is no experimental work to account for these volume changes. Their progressive nature as the cement hardens in water or air make it evident that they are connected with the chemical processes of hardening. Since the hardening of cement is recognized as being essentially a process of colloid formation and change, it may seem not unreasonable to hold that the changes are connected with the volume of the colloid water. The nature of the volume changes as cement changes from the dry to the wet state is in harmony with this view. It is probable that the volume changes are also due in part to purely capillary phenomena for sandstone and other building stones expand when wet and contract when dry. The amount of the expansion and contraction of concrete decreases as less cement is used so that it appears that the changes are more a function of the cement than of the mineral aggregate.

The subject has not been sufficiently studied to show how far such factors in the manufacture of cement as chemical composition, temperature of burning, fineness of grinding and rate of setting influence the result; nor how far conditions surrounding its use such as amount of water, temperature of air, etc., affect it. Until the influence of these factors has been determined it will not be possible to make intelligent progress towards lessening the volume changes and increasing the reliability of structures containing Portland cement. The subject is of such importance as to merit most thorough investigation from both the chemical and mechanical side on a larger scale than has yet been attempted.

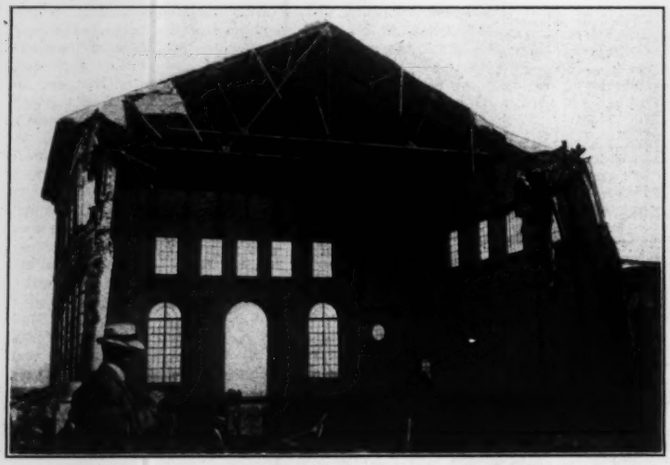
CONCLUSIONS.

Concrete hardening in a moist place and remaining continually moist throughout its life expands slightly but the compression stress developed in the concrete is probably not large enough to be injurious.

Concrete hardening in air and remaining continually dry contracts. The contraction is roughly twice as much as the expansion of concrete continually damp. This greater stress is harmful not only on account of its magnitude but because it puts the concrete in tension where it is weakest. It introduces an error of unknown magnitude into the calculations for all reinforced beams. It is responsible for the cracks in the top coat of interior cement floors. Fortunately most of the bad effects become evident within three months.

Cement sidewalks, pavements and stuccos exposed to the weather contract when they are dry and expand when they are wet. The richer the mixture is in cement, the greater is the volume change so that there is a differential expansion between the top coat and base of sidewalks which is often sufficient to split the two apart. So also rich stucco may be split from brick. In damp climates irregular expansion occurs apparently for as long as 20 years. Its harmful effects may not appear for many years. Large expansion joints are necessary in sidewalks and pavements.

Rich stuccos will inevitably crack through expansion and contraction and may be ruined. The few experiments made indicate that integral waterproofing compounds do not prevent or lessen the changes in volume. The only safety seems to lie in the use of lean mixtures whose volume change is slight. A stucco coat is inadequate as a protection for metal lath. If it is rich enough to keep water out it will crack. If it is lean enough to avoid the cracks water will go through it freely. In a dry climate the tendency is for sidewalks and stuccos to shrink more than they expand. Under these circumstances they will be much more durable and because of the slower corrosion stucco may be permissible as a protection for wire lath.



VIEWS OF THE COLLAPSED WATER-WORKS PUMPING STATION AT BUFFALO, N. Y.

Collapse of the Porter Ave. Pumping Station at the Buffalo, N. Y., Water-Works.

[From a Special Correspondent.]

At 9.15 a. m., Friday, June 30, 1911, a large part of the roof of the Porter Ave. Pump House of the new water-works plant at Buffalo, N. Y., fell, dragging down the side walls and carrying several workmen to instant death. Eight bodies have been recovered from the fallen mass of brick and steel. The men were engaged in placing the tile which were to cover the reinforced cinder concrete roof. The new station is to take the water from the recently completed tunnel* which reaches far out into Lake Erie, and pump it into the distributing mains reinforcing the old pumping plant that has been declared inadequate to supply Buffalo's exceedingly generous use of water.

The wrecked building is 100 ft. wide by 300 ft. long with walls 53 ft. high; 23 trusses supported the roof, 15 of which, in the central portion, are now crumpled up in the pump pits below. Four trusses under the hip roofs at both ends remained in place when the others fell, the end walls and hips affording sufficient resistance to the forces that dragged down the middle portions of the sides. A lantern extended along most of the ridge. The design of the building was prepared by Mr. R. A. Wallace, and the contractor was the B. I. Crooker Co.

The roofers had their materials on platforms inside the lanterns over the peaks of the trusses and were passing in and out of the open sides distributing and placing the tile.

The roof trusses, which were of the conventional type, were 100 ft. long and about 25 ft. high in the center and were supported on steel columns encased in brick pilasters. These columns were made up of two members, an 8-in. I-beam on the outside and a 10-in. I-beam on the inside, the inner stopping 12 or 15 ft. below the roof and surmounted by a longitudinal I-beam which formed one rail for traveling crane.

An intelligent and entirely credible witness standing within 100 ft. of the front of the building described the fall as of 15 seconds duration. Right in the middle of the long roof he first noticed a settling which spread north and south in two waves accompanied by a loud buzzing noise but with no sharp reports of rupture. Before the side walls moved at all the whole roof appeared quite flat to him and not until the entire upper structure had settled to the level of the top of the columns was there any breaking of the sides. The weight of the falling mass bent the outside columns down over the longitudinal I-beam, pulling both sides in under 13 trusses. Four columns, two at each end, received enough help from the end walls and hips to stand and their trusses broke away from the connections.

The four bent over end posts with sway braces attached, at the corners of the wrecked portion, furnish ample evidence of the direction of the moving mass. No part of the roof or walls fell outside the lines of the building. After the collapse the brick sides laid in the bottom almost as smoothly as floors covering the crumpled trusses below.

U. S. troops from Fort Porter near by and the police and fire departments rendered first aid and valuable assistance in rescue work, which is now being continued night and day by the by the Mayor and one by the District Attorney are now in progress.

(*A description of this tunnel appeared in Engineering News, Feb. 9, 1911, p. 153.)

Annual Convention of the American Institute of Electrical Engineers.

The twenty-eighth annual convention of the American Institute of Electrical Engineers was held at the Sherman Hotel, Chicago, June 26-30, with a large attendance of members and visitors, the total registration being 930 on June 29. There were ten business sessions for the presentation of papers, but in two cases parallel or simultaneous meetings were held, one being for the consideration of a special class of papers; these special meetings were for high-tension transmission and telephone work respectively. One of these suggested the tail wagging the dog, the attendance at the high-tension transmission meeting being much larger than that at the parallel general meeting. One meeting also was devoted to a discussion of the organization, work and policy of the sections which form subdivisions for carrying on the work of the Society.

The excursions included trips to the Hawthorne plant of the Western Electric Co., the power plants of the Commonwealth Edison Co., and the steel works of the Indiana Steel Co., at Gary, Ind. There were also a number of entertainments, including a general reception, an evening steamboat ride on Lake Michigan, and special entertainments for the ladies.

The proceedings opened with a brief address of welcome by Mr. Maclay Hoyne, one of the attorney's of the Corporation Counsel's office. The presidential address was then read by the President, Prof. D. C. Jackson, after which a brief address was made by the president-elect, Mr. Gano Dunn. The president's address was on the subject of "Electrical Engineers and the Public," and presented the public-utility question largely from the point of view of the public-utility corporation. It is true that the necessity of public regulation of such corporations was recognized, but more stress was laid upon the importance of the corporations and their work as affecting the public than to the benefits granted liberally (and not always wisely) to the corporations by the public.

Appraisals and Depreciation.

These closely related subjects were dealt with in two papers, and received some considerable discussion. Mr. Henry Floy's paper on "Depreciation as Related to Electrical Properties" was very much the same as the one he presented at the convention of the National Electric Light Association, which was noted in our issue of June 8. He thought that there should be a clear recognition of the difference between absolute (or actual) depreciation and theoretical depreciation of plant and property. He pointed out also that there is great necessity for a more general agreement upon and uniform use of various terms employed in discussing this subject. A paper by Mr. H. M. Byllesby on "The Responsibilities of Electrical Engineers in Making Appraisals" dealt largely with the development of electrical engineering and with the growth of public-utility corporations under the old system of liberal franchise grants. Coming to a consideration of the specific subject of the paper, the author pointed out the new responsibilities put upon the engineer in making appraisals to determine the value of the property of public service corporations. The gist of the matter was that engineers' estimates usually fall below the mark of actual cost, and that in making appraisals an engineer should recognize this tendency and should "apply to his estimate his own factor of individual inaccuracy." He laid stress also upon the great consideration which, in his opinion, should be accorded to the capital which enables the engineer to carry out important projects.

In this paper and the discussion which followed, as well as in the presidential address, the position taken was the corporation side rather than the public side of the matter. While the necessity of rendering good service and the desirability of public regulation of public-utility corporations were mentioned, the general tendency of the speakers was to present the corporation and the capitalist as great benefactors and beneficent institutions, entitled to very generous treatment by the public. This is true within certain limits, but in most cases these great enterprises could not have been undertaken without the very generous treatment which has been granted by the public. And it must be said that in very many cases the behavior of the "capital" side of the enterprise has not been such as to give the "public" side any very high idea of its beneficence or disinterestedness. It must not be forgotten that such enterprises are undertaken primarily for the financial benefit of the "capital" which backs them, and that capital has been so imbued with the idea of its own importance that the "utility" has seemed to it mainly a means of obtaining a return on the investment, with public service as a secondary consideration.

In the discussion, Mr. B. T. Arnold was about the only speaker to refer to the fact that great consideration is due to the public as well as to the capitalists. In the early days of public-utility corporations these corporations failed to give due recognition of the public interests, with the result that when the public attained a position where it could exercise control, it proceeded to accord to the corporations the same sort of treatment which it had received from them. At the present time, however, there is a better understanding of mutual rights and a tendency to fair treatment, as the public is becoming educated to a proper appreciation of the situation. The view of other speakers, however, was rather to the effect that the public must be educated to a due conception of the importance and beneficence of the corporations. Mr. Doherty referred to the value of the two papers in calling the attention of the engineers to this feature of their work; it is important that they should study the principles underlying such matters as appraisals and depreciation, and not leave these matters to be dealt with by the legal departments, which have not the requisite technical knowledge.

Railway Electrification.

Three papers were presented dealing with this subject. In a paper on "Induction Machines for Heavy Single-Phase Motor Service," Mr. E. F. W. Alexanderson dealt with the possibilities of a system of operating polyphase motors from a single-phase current, particularly where a heavy starting duty is required. He stated that by his system he has

succeeded in prodducing a balanced polyphase current by an apparatus which in cost and weight is only a fraction of the driving motors, the motors being ordinary polyphase motors with the same starting and running characteristics as such motors used on ordinary polyphase circuits. The possibilities of the induction motor for single-phase power are far from exhausted, although they have for a number of years been almost neglected or disregarded. Realizing that polyphase induction motors are by far the most economical form of power equipment, and that an addition of 15% to the weight of the electrical equipment will adapt the same for single-phase power with the same output and starting torque, the subject might be reopened for serious consideration.

A paper on "The Electrical Operation of the West Jersey and Sea Shore Ry.," by Mr. B. F. Wood, presented the costs of construction and operation of this high-speed third-rail line, the information being obtained with the permission and cooperation of the Pennsylvania R. R. The third paper was a lengthy one by Mr. Wm. S. Murray, entitled "Electrification Analyzed, and Its Practical Application to Trunk Line Roads, Inclusive of Freight and Passenger Operation." Its purpose was to advocate the universal use of single-phase current on trunk-line railways, including suburban and terminal territories and for both freight and passenger service. He proposed as the standard 11,000 volts on the contact wire and a system frequency of 25 cycles. One of the most interesting features of this paper was a reference to two freight yards on the Harlem River branch of the N. Y., N. H. & H. R. R. (with 20 and 42 miles of track) which are being electrified and will be operated by electric switching engines. These engines are of the 0-4-4-0 type, with a 600 HP. motor to each axle.

The discussion opened with a long address by Mr. F. J. Sprague, whose main points were that electric traction has been proved adaptable to every sort of service that is handled by steam locomotives, and that there is no one system of electric traction offering such advantages as to exclude other systems from consideration. He outlined, also, the great economic advantages of utilizing current generated at one great power station instead of having a number of individual power stations. Referring to the proposed electrification of the terminal lines of railways entering Chicago, he predicted that when this becomes a reality there will be a consolidation of interests in one central plant. Some brief remarks upon the Chicago situation were made by Mr. L. C. Fritch, Chief Engineer of the Chicago Great Western Ry. He said that there was no question as to the capacity of the electric locomotive to fulfill all the functions performed by steam locomotives. The difficult and important work at Chicago is the revision of the terminal lines, which have developed into an utterly complicated network.

Mr. D. C. Jackson said that there was no question as to the possibility of both the direct-current and alternating-current systems for railway service, and that there is no necessity for adopting any one system as a universal standard. In such a case as Chicago, however, under the conditions of the close association and interconnection of various railways, it would be "criminal" for the large roads to adopt different systems. The fundamental question now is not the practicability of electric traction for trunk line work, but the cost of operation; can it be adopted without increasing the cost of service? The system is too new for many reliable figures to be determined, and very few figures are available, but experience so far indicates favorable results and that electric traction is as applicable economically to heavy trunk line service as to interurban lines and street railways. The advantages of storage batteries for power plants in railway service were considered very small by some speakers, while others pointed out the extensive use, and one expressed the opinion that certainty of service of a large power plant is impossible without the use of batteries.

Other Subjects.

The two subjects noted above were the most significant and received probably more careful attention than any others. Many of the other papers, however, received a good share of attention; some of these related to specific technical matters, while others were of a more general character. We give below a brief review of the several papers.

CENTRAL STATION WORK.—A paper on "The Development of the Modern Central Station" was presented by Dr. Charles P. Steinmetz, reviewing the different features of this development. Among other things, he stated that the industry had been slow to realize the importance of reactance in giving safety and corresponding reliability to high-power generating systems. This is due to the prejudice acquired in the early days of the single-phase high-frequency systems, when the reactance in generators, lines and transformers spoiled the desired voltage regulation. But under present conditions it affords the most effective means of voltage regulation by phase control. The two problems now before the central station are (1) the localization of any disturbance by power-limiting reactances, and (2) the synchronous operation over lines of limited power by speed control of the prime movers.

In line with the above subject were two papers dealing with experiments as to the short-circuiting of generators of 12,000 KW. in the Fisk St. station of the Commonwealth-Edison Co. (Chicago). As continuity and uniformity of service are of the utmost importance, it is necessary to find some means of limiting the amount of energy which can flow into a fault. In the paper on "Power-Limiting Reactness with Large Turbo-Generators," by R. F. Schuchardt and E. O. Schweitzer, it was stated that the solution of this problem in some turbo-generator installations will be probably by the installation of current-limiting reactances. The tests indicate that the instantaneous short-circuit current is not as large as had been supposed, but that (owing to its comparatively high power-factor) it produces severe stresses on the generator and strains the oil switches. It is desirable to have a higher value of reactance in the generator circuit than many of the large generators are designed for. An external reactance of 6% ap-

peared to be desirable for the 12,000 KW. machines that were tested. The other paper was by E. B. Merriam, on "Tests of Oil Circuit Breakers." The devices under test opened all of the loads on short circuits without producing external disturbances or developing undue pressures. In some cases oil was thrown out, but after several short circuits this amounted to only 5%. It showed the necessity, however, of placing the circuit breakers in fireproof compartments.

In the discussion it was remarked that a generator with external reactance is better than one designed for high internal reactance, as there will be less trouble from short circuiting with the former machine. It was stated also that the use of reactances made it unnecessary to redesign the switches for handling high power. Mr. Lamme, however, thought that external reactance should be provided for only when absolutely necessary. As to oil switches, different speakers advocated the vertical-break type and the horizontal-break type.

ELECTRIC CONTROL SYSTEMS.—A system of "Automatic Motor Control for Direct Current Motors" was described by Mr. Arthur C. Eastwood, and is designed to avoid the trouble and damage due to careless handling of the starters of motor-operated machinery. The liability to such trouble is increased where the motor is to be reversed as well as started. In the reversing tables of rolling mills this trouble made the use of electric motors practically impossible until a control system was introduced, so that the operator had simply to handle a lever and watch the table, without attempting to act as a motorman in regulating the current. The control of high-speed passenger elevators was dealt with by Mr. T. E. Barnum in a paper on "Elevator Control." He considered that the gearless machine has the advantage in mechanical simplicity and efficiency. In the geared machine, the lower mechanical efficiency (which is really a safety factor, since it means a reduced tendency to run away), is compensated for by the increased motor efficiency. A third paper on the same general subject was one on "Some Limitations of Rheostatic Control," by L. L. Tatum and G. R. Radley. There was very little discussion on these papers.

ELECTRICALLY DRIVEN REVERSING ROLLING MILLS.—In ordinary rolling mills operated electrically, heavy fly-wheels are commonly employed to regulate the load conditions, but in the reversing rolling mill the fly-wheel effect must be reduced to a minimum so that the accelerating force may be kept within reasonable limits. In the paper by Mr. Wilfred Sykes there was a list of 35 installations of this kind, three of which are in this country. The universal method of control is by regulating the generator field. The Illinois Steel Co. has a two-high universal plate mill which was put in operation in 1907 and can reduce slabs 30 × 7 ins. to ¼-in. plates. This is driven by two d. c. shunt-wound motors, with a total of 8,000 HP. at 100 r. p. m.; their speed can be increased to 150 r. p. m. by weakening the field, but they start always on full field. The rotating parts of the two motors weigh about 123,000 lbs. The motors are operated from a motor-generator set of 6,500 KW., the speed of which is regulated by an automatic slip regulator.

HIGH-TENSION TRANSMISSION. — Three short papers, which were mainly descriptive, dealt respectively with the transmission systems of the Great Western Power Co., in California (J. P. Jollyman); the Southern Power Co., in North Carolina (W. S. Lee); and the Great Falls Power Co., in Montana (M. Higben). All these plants carry 100,000 volts on the line, the length of line being 153, 96 (and 161), and 282 miles respectively. A paper by G. Faccioli, on "Electric Line Oscillations," dealt with tests made by the first-named company to obtain information as to oscilations and rises of potential in the 100,000 volt line, due to switching operations. Mr. Wm. L. Robertson presented "A Solution to Problems in Sags and Spans," accompanied by numerous formulas and diagrams, and a paper by Mr. P. H. Thomas discussed "Sag Calculations for Suspended Wires." A paper on "Mechanical and Electrical Characteristics of Transmission Lines," by Harold Pender and H. F. Thomson, was mainly of a mathematical character, and was intended to present in compact form the formulas (and their derivations) required in the determination of these characteristics.

TELEPHONE AND TELEGRAPH WORK.—A separate meeting was held for the consideration of papers on these subjects, being held at the same time as one of the general meetings. In each room a notice was displayed of the paper then under consideration in the other room, so that members interested in any particular paper were advised as to its presentation. The paper by Mr. Bancroft Gherardi on "The Commercial Loading of Telephone Circuits in the Bell System," dealt with the very great improvements effected by the method patented in 1900 by Prof. Pupin; it was of a similar character to the paper by the same author which was published in our issue of May 25. Mr. George D. Squier described a system of "Multiplex Telephony and Telegraphy by Means of Electric Waves Guided by Wires," in which it was stated that the plant efficiency of the best wireless stations is so low that it cannot be compared with even the least efficient transmission of energy by conducting wires, and experiments made by the U. S. Signal Corps indicate the value of a metallic guide wire for the energy of electric waves. Mr. F. F. Fowle in a paper on "Telegraph Transmission," dealt with the improvement of telegraph operation by means of improvements in relays, in terminal conditions and in line insulation. This last may be effected by reducing the number of poles (and insulators), but this is rarely practicable; greater possibilities are offered by the use of better forms of insulators, some of which were illustrated. Among these was the suspension insulator (Engineering News, Aug. 8, 1907), and "The High Efficiency Suspension Insulator" was the subject of a paper by Mr. A. O. Austin.

ELECTROLYTIC CORROSION IN REINFORCED CONCRETE.—In this paper by C. E. Magnusson and G. H. Smith, details were given of a series of tests made to secure some definite information upon this important subject. We give particulars of the paper and the discussion on another page of this issue.

MISCELLANEOUS.—Two papers were practically continuations of the discussion at the 1910 meeting as to the voltage point at which air ceases to be an insulator for electric current and at which the line losses consequently become excessive. One of the conclusions of the paper by J. B. Whitehead, on "The Dielectric Strength of Air," was that stranding a conductor lowers the critical voltage. The paper on "The Law of Corona and the Dielectric Strength of Air," by Mr. F. W. Peck, Jr., described at considerable length an extensive investigation carried on under the supervision of Dr. C. P. Steinmetz.

Among the other papers we mention the following: "The Cost of Transformer Losses," E. C. Stone and R. W. Atkinson; "The Application of Current Transformers in Three-Phase Circuits," J. R. Craighead; "Economical Design of Direct Current Electro Magnets," R. Wikander; "Wave Shapes of Currents in the Rotor Conductor of a Single-Phase Induction Motor," H. Weichsel; "Rotor Diameter and Performance of Polyphase Induction Motors," Theodore Hoock, and "A Tentative Scheme of Organization and Administration for a State University," R. D. Mershon.

THE NEW STEAMER "CAMERONIA," of the Anchor Line, which is to go into service in August, is the largest steamer in the Anchor Line fleet of transatlantic steamers, and the largest also to run regularly from the port of Glasgow. It is 530 ft. long over all, 62 ft. beam, 38½ ft. deep, 10,500 tons measurement and 17,000 tons displacement with full cargo. The twin-screws are driven by two triple-expansion four-crank engines, of 11,000 I. HP.; steam is supplied by six double-end and three single-end marine boilers, carrying 200 lbs. pressure. There are two funnels and two pole masts. There is accommodation for 1,560 passengers (first, second and third classes). The steamer (including engines and boilers) was built by D. & W. Henderson & Co., of Partick, Glasgow (Scotland), and is the 34th steamer built by this firm for the Anchor Line. It will run between New York and Glascow, in service with the "Columbia," "California" and "Caledonia," which are only slightly smaller.

Annual Meeting of the American Society for Testing Materials.

The annual general meeting of the American Society for Testing Materials, held at Atlantic City, N. J., June 27 to July 1, 1911, gave evidence of continued growth of vitality and activity in the society. Over 300 members and nearly 150 visitors and ladies were at the meeting, the total registration exceeding 450. These figures carry much meaning when it is remembered that the society numbers only 1,400 members; the meeting was active and energetic in corresponding degree.

While the record of the previous meetings of the society may make such observations seem rather trite, yet the present meeting had a distinctly individual character, and clearly marked a new stage of development of the society. The committee work, which has long been the most concentrated part of the society's activities, has evolved into a new and more systematized form, which promises to yield markedly increased efficiency. The latter is evidenced by the number and kind of new specifications brought forward at the present meeting, which will be seen to be none the less notable because dealing with matters less burning than the steel rail problem. Moreover, nearly all of the new specifications and revisions went through smoothly, with a minimum of discussion and practically no protests at the meeting. Such a result might perhaps come from laxity and low interest at the meetings, or might follow from the greatly broadened scope of the specification work. But the former condition did not exist, and there were many evidences that the interest and participation of the meeting was fully as close and intelligent as when only a narrow range of specifications was discussed. It seems clear that the favorable outcome of the committee reports is chargeable to the efficiency of working in the committees themselves.

The arrangement of committee work has undergone a pretty thorough reorganization during the year, in part by concentration and in part by specialization. Work has been centralized by materials or subjects; on the other hand, the larger committees have subdivided and grouped their work in charge of separate subcommittees, so that the details may be in the hands of a small, compact group of men. Thus, the Steel committee is now grouped in eleven subcommittees, the Cast-iron committee in nine, and the Paint committee in nearly as many. And the latter committee, for example, has had important work of large extent in progress in each of its subcommittees during the year, so that its report of progress gave promise that our knowledge of paints and protective coatings will soon be materially advanced as a direct result of the work in hand.

It seemed almost that the progress reports presented by committees were more important than the reports which offered finished specifications. Such a view doubtless would be unjustified as a serious estimate of achievement; yet that an impression of the kind even could exist is proof of the sound and progressive condition of the society.

The usual list of excellent papers rounded out the technical sessions. Some of them described new testing apparatus, or new methods, or results obtained therewith; others described observations on materials or structures, and thus added to the knowledge of materials and their service. The papers as well as the committee reports will be briefly reviewed farther below.

Several other things besides the excellence of the convention mark the current year's operations of the society. Most important, in one sense, is that the increase of membership dues—from a nominal sum to one more reasonably proportionate to the cost of the service rendered the member—turned out to be a complete success; the society is now on a sound footing financially, and the loss of membership which was feared did not materialize. The treasury has a safe surplus, and by virtue thereof the society will, as Secretary Marburg put it, pay an extra dividend in the shape of an index of the first ten volumes of Proceedings, which closed with 1910.

The publication of a Year-Book (issued in 1910 for the first time) which brings together all the specifications, test codes, etc., promulgated by the society, together with a membership list, committee lists and other record information, was not only a success in itself, but it led to an unforeseen result which is likely to prove important for the future specification work. The juxtaposition of all the specifications brought to the surface numerous differences of form, a condition undesirable in itself and containing the possibility of lack of harmony. This led the Executive Committee to examine the need for a code of standardization of form; a special committee reported that such a code is desirable and necessary, and on this report the meeting authorized the establishment of a committee to prepare and submit a code as described. The code is to deal with the form without affecting the substance of specifications. As the number of standard specifications is rapidly increasing, the Year-Book will soon be a volume of some bulk and complexity; unity of form will become increasingly important under these conditions.

An innovation of related character that is planned is the establishment of a committee to examine papers submitted for presentation at the meetings of the society. The effect of this would ultimately be to secure greater compactness, and perhaps on the whole also a better average grade, of technical papers than can be attained under the present absence of all censorship.

A new departure was made at the present meeting in two points, which may establish a precedent of moment as to the general nature and objects of the society. Hitherto the society has limited its specifications to materials and to testing methods, and it has put forward for public use only finished specifications, i. e., such as could at the time of adoption find approval as "standard." Both these limitations were departed from at the meeting of last week. The Committee on Heat Treatment of Iron and Steel brought out a report giving full general rules for commercial heat-treatment work. This is not a specification of material, nor does it represent or involve testing methods. Yet it was proposed for adoption as a standard code, and against some protest the meeting assented to this. Later, a group of specifications for tests of road materials was presented by the committee in charge as "provisional," but (in violation of past custom to hold such specifications virtually in the hands of the committee until they could be recommended as definitive) the committee asked that the society vote on them and pass them as "provisional." The meeting did not object, but passed them to letter-ballot for adoption as provisional specifications.

Another new precedent was barely avoided at the last session of the meeting, when Mr. J. G. Brown (Philadelphia, Pa.) moved that the society endeavor to interest proper authorities in fuller determination of wind pressure on buildings. After some discussion, which indicated that the matter in question was outside the society's field and that the action asked for would therefore be rather inappropriate, the difficulty was disposed of by withdrawal of the motion.

Congress of International Association in the United States, 1912.

Preparations are under way for receiving the International Association for Testing Materials next year, the Copenhagen congress in 1909 having decided that the next congress should meet in the United States in 1912. The Congress will be held in autumn, probably in September (the precise dates have not yet been fixed). The society of course will participate in the Congress to an important extent, and it has charged itself with making many of the local arrangements.

Under these circumstances the Executive Committee concluded that it would be desirable to limit the 1912 meeting of the society to committee reports and general business, to the end that interest might be centered more strongly in the Congress which occurs a few months later. This decision was approved by the meeting, and was referred to letter-ballot of the society for final approval. Further, the Executive Committee proposed to make a substantial contribution to the International Association, in return for which each member of the Society would receive a copy of the English edition of the Transactions of the Congress. This proposal also was sanctioned by the meeting. The Junior class of membership established a year ago is included in the arrangement only partially, Juniors being admitted to the full privilege on payment of $2.50 in addition to their regular dues. Those members of the Society who belong to the International Association will in any event retain the advantage of receiving the advance papers and having a vote in the Congress.

The local Organizing Committee, composed of the chief officers of the Society, has already made the preliminary outlines of the work in preparation for the Congress, but a great amount of detail preparation will have to be done during the next eighteen months.

Business Proceedings of the Meeting.

President Henry M. Howe (Columbia University, New York City) presided at the opening session of the meeting and indeed generally, but in accordance with precedent several of the later sessions were conducted by men specially interested in the subject of the session. This arrangement, though in some respects ideal, did not at all times work with perfect smoothness, as the eagerness of discussion sometimes made the substitute chairman forget the difference between presiding and entering as partisan into the discussion. This was not without its humor, as when, in the discussion of an important series of observations on shrinkage and swelling of mortar and concrete, the decay of an old concrete sidewalk being mentioned, Mr. R. W. Lesley (American Cement Co., Philadelphia, Pa.) remarked from the chair that a brick sidewalk would doubtless have shown the same decay under the circumstances of the case.

Nine sessions were grouped in the five meeting days, and as but little time was needed for business proceedings the meeting went through a great amount of technical work. However, the arrangement followed this year and in 1910 was markedly less strenuous than that of earlier years, when three sessions a day and occasional duplicate sessions were practiced.

The International Association Congress in 1912 received consideration as already noted. The Society's annual business report, furnished in printed form, was passed without discussion. The official nominees for members of the Executive Committee were duly elected, as follows: Mr. W. A. Bostwick (Orford Copper Co., New York City), Mr. R. W. Hunt (Inspecting Engineer, Chicago, Ill.), Mr. Richard Moldenke (Metallurgist, Watchung, N. J.), and Mr. W. R. Webster (Civil Engineer, Philadelphia, Pa.). Several minor formal changes in the By-Laws were approved.

We note from the report of the Executive Commitee that the increase of dues to $10, together with increase of membership and expansion of general business, resulted in a present balance of $6,800 in addition to paying off the 1910 deficit of $2,200. The total surplus for the year's operations of $9,000 was achieved in spite of the increase of service by publishing the new "Year-Book." As already mentioned, the surplus will be taken advantage of by preparing and publishing an index of the Proceedings to 1910 inclusive. The membership of the Society has grown by 102 net, to 1,382; the gain in the five years past was 547. For international specification work the sum of $250 is to be contributed to International Committee 1-A, even though the Engineering Standards Committee (England), which was supposed to make a similar contribution, has declined.

President H. M. Howe read a scholarly presidential address, dealing with the advance of the art of testing, and the future of the great work of specification drawing which the American Society has taken for its chief field of labor. We wil give an abstract of the address in our next issue.

A condensed review of the technical work of the meeting is given below. In considering this, it should be noted that only about half the reports and papers were before the members in printed form, and those which were read from MS. were generally presented in abstract only. Since moreover none of the matter had been sent out prior to the meeting, the discussion could not be full and specific. The present meeting was the same as all previous ones in this respect, but on account of the growing ambitions and needs of the Society the condition is felt more strongly. The management is therefore planning to improve things by requiring all matter to be in the hands of the secretary well in advance of the meeting, so that printed copies may be placed before the members before the meeting, in time to prepare for cogent discussion. As two years will elapse before another full meeting of the Society, it ought to prove possible to carry the plan into successful effect.

The condition was somewhat aggravated by the fact that several unannounced committee reports and papers were added to the program, and several of those announced in the program were represented only by their titles.

NEW AND REVISED SPECIFICATIONS.

Locomotive Cylinders.

Committee A-3, on Cast Iron and Finished Castings (ch., Walter Wood, of R. D. Wood & Co., Philadelphia, Pa.) is now organized in nine subcommittees, of which six are in charge of the specifications for as many different kinds of casting, and three deal with separate general questions. The outcome of the past year's work was the revision of the existing (1904) specification for locomotive cylinders, though the committee did not ask the Society to adopt the new form, but prefers to have it held for longer consideration. Probably this is because a radical novelty is introduced in the new specification. The transverse test is abandoned as primary criterion of physical quality, and a chill test is offered in its place, still leaving the transverse test optional with the purchaser. The chill test-piece is a small ingot, slightly wedge-shaped, of 2 ins. mean width by 2 ins. depth. The bottom has a right-angle notch ½-in. deep, at midlength. This ingot, cast in a chill mold, is to be quenched in water from dark red, and then broken. The fracture must show

a close-grained, well-mottled gray iron, with a well-defined border of white iron at the bottom of the fracture.

No action was taken by the meeting.

Steel Car-Wheels.

The committee on specifications for steel (Comm. A1, ch., W. R. Webster, Philadelphia, Pa.) has divided its detail work among eleven sub-committees. Three of these worked out four new specifications, which were presented to the Society for adoption.

Two of the four specifications deal with forged and rolled, forged, or rolled solid steel wheels for (1) engine truck, tender, and passenger subway and elevated railway service; and (2) freight-car service. Discussion at the meeting brought out some conflicting views, chiefly as to whether the permitted range of carbon was narrow enough to give wheels of sufficient durability and uniformity. The opinion was expressed also that since the steel wheel is a new product, there is not yet very extended experience with it, and standard specifications should not be established too hurriedly. This view prevailed, and the two proposed specifications were referred back to the committee.

Heat-treated Axles and Shafts.

A specification for Heat-treated Carbon Steel Axles, Shafts and Similar Parts was passed to letter-ballot of the Society. It limits carbon to 0.60% maximum, manganese to the range 0.40% to 0.80%, and phosphorus and sulphur each to 0.05% maximum; the general analysis is to be made on drillings from the crop end of a finished part, but the phosphorus limit must also be met by analysis from the tensile test piece. A tensile strength test is to be made for each open-hearth and each treating-plant heat, on a standard 2-in. test-piece ½-in. in diameter. The figures called for are:

Ultimate strength	85,000 lbs./in.²
Elastic limit	50,000 lbs./in.²
Elongation in 2 ins.	22%
Reduction of area	45%

The elastic limit is to be determined *by extensometer*. A cold-bend test is also required for each heat: a ½-in. square bar to bend 180° around a 1-in. diameter.

Before the vote went through, the specification was criticized by Mr. S. V. Hunnings (Engr. of Tests, Amer. Locomotive Co., Schenectady, N. Y.) and others, for fixing the carbon limit (0.60% max.) too high. For the committee, Mr. A. A. Stevenson (Vice-Pres. Standard Steel Works Co., Philadelphia, Pa.) replied that the committee preferred to give no figure whatever for carbon, letting the test requirements take care of quality, but had finally given a guide figure, although the physical tests would usually keep the carbon below this figure.

Steel Reinforcing Bars.

This, the last of the four specifications presented by Committee A-1, was also passed to letter-ballot, with no discussion. It gives separate strength figures for five grades: Structural grade plain and deformed, hard grade plain and deformed and cold-twisted bars. In chemical composition only phosphorous is specified; the limit is the same for all grades, 0.10% for Bessemer and 0.05% for open-hearth steel. Numerous other interesting points are contained in this specification; we will reproduce the full text in our next issue.

Hard-Drawn Copper Wire.

Mr. J. A. Capp (General Electric Co., Schnectady, N. Y.), chairman of Committee B-1 on this subject, reported that after much experimental research it had prepared a revision of the specifications adopted two years ago. Extensive tests of wire were carried out in the interim, including some 1,500 individual tensile tests; these showed (1) that the prescribed method of measuring elongation on 10-in. gage-length was unworkable in the case of small gages of wire, and (2) that the strength table needed some alteration. In the revision it is specified that on wires under 0.204-in. diameter the elongation is to be the *total* measured *on a 60-in. length between the jaws of the machine*; on larger wires it remains as the *permanent* elongation on a 10-in. gage-length. Brazes in the wire must show 95% of the strength of the wire. The strength table is slightly revised, in accordance with the tests made and the change of method of measuring elongation. Also, in the larger sizes distinctly greater elongations have been found practicable. A specification for figure-eight trolley wire is also included in the revised form.

The committee was unanimous in reporting the revision, and recommended that the specification be passed to letter-ballot, to which the meeting assented.

Heat-Treatment Procedure.

The work of Committee A-4, on Heat Treatment of Iron and Steel, resulted in a code of general guiding rules for conducting commercial hardening and annealing. This was submitted to the meeting by President H. M. Howe, chairman of the committee, under the title Recommended Practice. He asked for letter-ballot approval the same as is customary for standard specifications, although the code of rules is by no means a specification and is not intended as such. This novel state of affairs led to some doubtings and opposition. Several members objected that the report was concerned with manufacturing methods and not at all with testing, and they held that it was not the business of the Society to prescribe methods of manufacture. Mr. R. W. Hunt (Chicago, Ill.) moved that the report be received and printed as a contribution (i. e., just as any paper presented before the Society). Much discussion followed, in which it appeared that a number of members would be willing to have this code of rules printed in the Year-Book, where all standard specifications are printed, but without giving the code the regular status by letter-ballot approval. The committee desired more than this, however, on the ground that the code, while not a specification, might be used by buyer and seller as *the basis for* a specification. The attitude of the committee ultimately prevailed, and the code will go through the regular letter-ballot course, and if adopted will appear in the Year-Book, although it will bear the title only of Recommended Practice.

We hope to give this code of rules in full, in the near future.

Copper Ingots and Bars.

Committee B-2, on Non-Ferrous Metals and Alloys (ch. Prof. Wm. Campbell, Columbia University, New York City), reported three specifications dealing with cast raw materials, and said that its work on wrought metal is progressing well. However, it has found the field assigned to it too large for unified treatment, and recommended that the work be made more specific by fixing definite subjects and questions to be worked on by the committee.

The specifications for Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars calls for a metal of at least 99.880% purity as determined by electrolytic essay (silver being counted as copper). The standard of conductivity (100%) is to be 0.15302 international ohms, which is taken to be the resistance of a meter-gram of annealed copper at 20° C. Referred to this standard, wire bars and other copper for electrical use is to have at least 98.5% conductivity, and ingot copper 97.5%, both in annealed condition; arsenical copper is to have at least 90% conductivity. The specifications fix methods of marking, sampling for test, etc. They were passed to letter-ballot without dissent.

Spelter.

Four grades of spelter are established by the proposed specifications. The maximum impurities allowed are:

Grade.	Lead.	Iron.	Cadmium.	Total not over
A. High grade*	0.07%	0.03%	0.05%	0.10%
B. Intermediate*	0.20	0.03	0.50	0.50
C. Brass special*	0.75	0.04	0.75	1.20
D. Prime Western	1.50	0.08	....	....

*To be free from aluminum.

Methods of sampling, analysis, and settlement of claims are prescribed.

The specification was passed to letter-ballot.

Manganese-Bronze Ingots.

The third specification of this committee is for manganese-bronze ingots. The chemical composition is prescribed as:

Copper	55 to 60%
Zinc	39 to 45%
Iron, not over	2%
Tin, not over	2%
Aluminum, not over	0.5%
Manganese, not over	0.5%

The standard ½-in. × 2-in. turned test-piece is to show at least 70,000 lbs. per sq. in. ultimate tensile strength, and at least 20% elongation.

There was some difference in the committee on this specification, partly on the score of the name, "brass" being thought more correct than "bronze." The specification was approved by the committee, however, and the meeting passed it to letter ballot.

Standard Methods for Transverse Tests.

A year ago Committee E-1, on Standard Methods of Testing, presented for adoption a code of testing standards, covering tensile tests of metals, compressive tests of metals, and metallographic tests of metals. This code was subsequently adopted by the society as standard. Now this has been supplemented by a code for transverse tests.

An important novelty in this code is that for transverse tests of cast metals it specifies a round bar 1¼ ins. diameter and long enough to give a span at least 15 times the diameter. This is a conscious departure from the 1¼ × 12 in. "arbitration bar" established some years ago (in other societies) for cast-iron tests. For other materials, it is recommended that the form of test-piece be made similar to the service form, as far as possible.

This code, reported by a sub-committee, had been approved by the main committee, E-1. It was passed to letter ballot.

Tests of Magnetic Qualities of Sheets and Rods.

Mr. C. W. Burrows (Bureau of Standards, Washington, D. C.), as chairman of Committee A-6, on Magnetic Testing of Iron and Steel, reported a specification for standard methods of magnetic testing, covering the determination of core loss and normal induction. Core loss of sheet steel is to be measured on a core of four 2½ kg. piles of 50 × 3 cm. strips arranged in a square, the piles being butted at the corners with a sheet of paper 0.01 cm. thick interposed; with primary and secondary windings each of 150 turns on each side of the square, alternating current being supplied to the primary of such intensity as to give a maximum induction of 10,000; a watt-meter connected with its current coil in the primary and its voltage coil across the secondary gives the total loss in core and secondary, from which the secondary resistance loss is then substracted. Aging coefficient is defined as the percentage change in core loss after heating the iron 600 hrs. at 100° C. Normal induction is to be measured on a circuit similar to that used for the core-loss test; the magnetizing forces corresponding to inductions of 2,000 to 20,000 gausses (varying in steps of 2,000) are to be measured. In the case of rods for use in electro-magnets, the Burrows compensated double yoke method is to be used (as described in Technical Paper 117, Bureau of Standards).

This specification was passed to letter-ballot for adoption as standard, without discussion.

Tests for Road Materials.

Committee D-4, on Standard Tests for Road Materials, reported specifications for four test methods for bitumens and paving aggregates. These were presented under the unusual title of "provisional standard specifications," and the society was asked to adopt them as such. Discussion showed that opinions differed on the desirability of approving "provisional standard" or even "provisional" specifications. Heretofore, when a committee was not yet willing positively to recommend a specification for adoption as standard, it has been customary to report the specification so that it would be open to the examination of all members of the society, but to hold it as "tentative," keeping it in charge of the committee until the latter was fully decided on the matter. This procedure was followed in the case of the Locomotive Cylinder Specification at this meeting. The Road Materials Committee apparently wanted to give its specifications a halfway standing, by having it approved without wholly committing the committee. The meeting voted, after discussion, that the specifications be passed to letter-ballot as "provisional specifications," the word "standard" not to be used.

PROGRESS ON SPECIFICATIONS AND INVESTIGATIVE WORK OF COMMITTEES.

While the newly drafted specifications recorded above represent a remarkably large amount of effective work, the reports of those committees whose work has not yet progressed to a point where definite specifications could be brought in, also showed a great deal of study and experiment. The surprising extent of the committee work done in the society became more evident at the recent meeting than at any previous one.

It is difficult to review these progress reports in such a way as to give an adequate idea of the kind and nature of the work under way and in prospect. To quote the wording of the reports themselves is not possible at this time; and even these reports, except in those cases where they contained an actual statement of work and results, gave but the most general idea of the labors of the committees. The following notes are therefore at best a very rough sketch of the aggregate of committee work.

Springs and Spring Steel.

A great amount of experimenting has been done by a sub-committee of Committee A-7, on Tempering and Testing of Steel Springs and Standard Specifications for Spring Steel. For preliminary purposes the committee adopted as chemical specifications for spring steel the following:

Carbon	0.90% to 1.10% (1.00% desired)
Manganese, not to exceed	0.50%
Phosphorus, not to exceed	0.05%
Sulphur, not to exceed	0.05%

A series of test specimens of steel meeting this specification (but ranging around the upper carbon limit) was obtained, and tests of transverse strength, hardness tests (Brinell), and drop tests were carried out on samples subjected to different heat treatments. The results were set forth in extenso, but they do not as yet warrant specific conclusions. The work is to be continued. Mr. Henry Souther (Hartford, Conn.) is chairman of the committee; the sub-committee which did the investigative work is headed by Mr. E. D. Nelson (Penna. R. R., Altoona, Pa.)

Paints and Preservative Coatings.

A most extensive progress report was submitted by Committee D-1, on Preservative Coatings for Structural Materials, chairman Mr. S. S. Voorhees (Engr.-Chemist, Bureau of Standards, Washington, D. C.). The work of this committee having been divided among numerous sub-committees, was reported separately by the chairmen of the latter.

Two items of special interest were the report on the Havre de Grace paint tests, on the Pennsylvania R. R. bridge over the Susquehanna River, and the report on the Atlantic City panel tests of protective mixtures. We hope to give these reports somewhat fully in another issue, as both groups of tests have been going on long enough to give valuable indications.

OIL ANALYSES.—The sub-committee on Linseed Oil has continued its analytical work. It is found that two years' storage (hermetically sealed) has had no appreciable effect on the original oils except to increase the acid number. The Bureau of Standards has measured the coefficients of expansion of these linseed oils between 4° and 40° C. An important result of the analyses is that the tests now in common use are not sufficiently discriminative of adulteration, so that it is desirable that other tests of purity be developed,

such as the hexabromide test, both on the oil and the fatty acids obtained from it, the acetyl value test, and the percentage of solid or saturated fatty acids present.

Boiled oil has not yet been included in analytical work, but committee has agreed that:

Boiled linseed oil should contain no appreciable amount of volatile matter.

The organic unsaponifiable matter in boiled linseed oil should not materially exceed that present in raw oil.

If resin compounds are present (whether they are allowable is still in dispute), the amount should not appreciably exceed what would combine to form normal compounds with the lead and manganese present.

For raw oil, the provisional specifications suggested in the 1909 report are regarded as fairly reliable for North American seed.

PAINT VEHICLES.—Experimental work on paint oils has been started by another sub-committee. The plan of work includes laboratory tests on time of drying and character of film, and exposure tests with a standard pigment. Different drying, semi-drying and non-drying oils are to be used in various mixture ratios, with varying amounts of driers. The laboratory tests on the oil films are made both with and without pigments. Some results so far obtained are that thin films take much more oxygen than thick films, and that in moist weather the films dry quicker and harder than in dry weather.

Work is in progress also on varnishes, and on the influence of pigments on corrosion. Another sub-committee is compiling a set of definitions of terms used in connection with paints and oils, to fix their meanings for the purposes of the work of the committee.

Corrosion Tests.

Mr. A. S. Cushman (Washington, D. C.) reported for Committee A-5 on Corrosion of Iron and Steel. The wire test fence erected at Pittsburg two years ago is still under observation; galvanized hot-dipped close-wiped wire has failed very rapidly in the two years.

The Preece copper-sulphate test for quality of galvanizing has been found unsatisfactory in the case of sheet and plate; the lead-acetate test is to be preferred. For wire the Preece test is convenient, and fairly accurate.

Sewer Pipe.

An elaborate program of inquiry concerning clay and cement sewer pipe has been formulated by Committee C-4 (chairman, Mr. Rudolph Hering, Consulting Engineer, New York City). The program is so comprehensive and ambitious that if it were followed out in full there would be no prospect of getting a specification for years, but it was explained that the actual inquiry will not necessarily go fully into each of the program items. The program, for example, puts the question: What physical and what chemical properties should be sought for in the clay from which a clay sewer pipe is made, in order to attain the desired strength, resistance to wear, etc.

The program is in three parts, covering the ascertainment of (1) the demands made upon sewer pipe, in the way of strength, wear-resistance, denseness, resistance to chemicals or to heat and cold, smoothness, shape of section, accuracy of form, etc.; (2) the methods of examination and testing for acceptance; and (3) the methods and requirements of laying sewer pipe in order to secure the most efficient result. When all three branches of the subject have been fully discussed, the result will be the basis for specifications.

Coal Specifications.

Mr. A. W. Belden (Bureau of Mines, Washington, D. C.), reported progress for Committee D-5, on Standard Specifications for Coal, chairman, Mr. J. A. Holmes (Director, Bureau of Mines, Washington, D. C.). The committee has not quite reached the point of reporting specifications. Extensive work has been done in collecting and analyzing samples of coal from different beds, over 1,000 samples having been analyzed to date. There is still some question as to methods of sampling, etc., suitable as standards.

Other Progress Reports.

Committee C-3, on Paving and Building Brick, has been changed by the withdrawal of Mr. L. W. Page; Mr. D. E. Douty (Bureau of Standards, Washington, D. C.) has taken his place as chairman. Separate sub-committees are working on paving brick and building brick. Work has not advanced far enough for specifications. Experimental studies of brick absorption and permeability were reported by Mr. Douty and Mr. L. L. Beebe in a paper noted farther on.

The Committee on Road Materials, whose report of provisional specifications was noted above, has several experimental investigations in hand, of which the studies for a standard method of distillation were given prominence. This study is progressing well enough to promise the early establishment of a standard method.

(To be continued.)

A BOILER EXPLOSION on the river steamer "City of St. Joseph," near Memphis, Tenn., June 24, caused the deaths of 17 persons. The accident occurred as the boat was passing President's Island, about six miles down stream from Memphis. The packet burst into flames but the fire was put out by streams from the pumps of a ferry boat.

A CYCLONE IN CHILE June 23 did an immense amount of damage to buildings in towns and to shipping in the harbors. One hundred loaded lighters were sunk at Iquique, according to reports, and our larger vessel went down, while at Valparaiso a four-masted ship and many smaller craft were driven ashore. The lighting system at Valparaiso was disabled. The whole loss caused by the storm is estimated at $10,000,000.

A GRADE-CROSSING ACCIDENT on the Long Island R. R., near Glendale, Long Island, July 2, resulted in the death of five people. A horse-drawn vehicle carrying six persons was struck by a westbound electric train on the Trotting Course Lane crossing of the Rockaway branch. The wagon was descending the grade leading to the railway tracks at good speed when the crossing flagman's warning was noticed. The horse became excited and the driver, a woman, was unable to stop it. The train was running at a speed of about 40 mi. per hr. when it struck the wagon. Five of those in the wagon, which was knocked to pieces, were killed outright, while the driver was seriously injured. The conductor and motorman, both on the front platform of the train, were injured by pieces of the wagon and by glass from the front vestibule of their car.

An automobile was struck by a Boston & Albany R. R. eastbound passenger train July 1 at Post Roads crossing, about 20 miles east of Albany, N. Y. Three of the four persons in the automobile were killed.

An automobile was hit by a trolley car at Warwick, R. I., July 4. Three of the five persons in the automobile were killed and the others badly injured. The accident occurred at a crossing where the view was cut off by thick bushes. The trolley car was running at about 40 mi. per hr.

A MOLD BURST June 27 in the foundry of the Otis Elevator Works at Yonkers, N. Y., during the pouring of a five-ton casting for a mine hoist. Eight men were badly burned by the flying molten metal, two so seriously that they died the next day.

A ROUNDHOUSE FIRE at Barstow, Cal., June 23, destroyed the machine shop and roundhouse of the Atchison, Topeka & Santa Fe Ry. and 16 locomotives. The loss is estimated at $400,000. The burned buildings were of frame construction. They will be replaced with fireproof buildings of reinforced concrete.

THE STEAMSHIP "SPOKANE," an excursion boat from Seattle, Wash., sank June 29 in the Seymour Narrows, off Vancouver Island, after striking on Ripple Rock. All but two of the 100 excursionists aboard were taken off safely in small boats. The two persons drowned were women, one being the wife of Mr. Gardner F. Williams, M. Am. Inst. Min. E., of Washington, D. C.

EARTH SHOCKS IN CALIFORNIA on July 1 at 2 p. m. are reported as the heaviest experienced there since the earthquake of 1906. They were felt as far east as Carson City, Nev. Slight damage was done to a few office buildings in San Francisco.

A NOTEWORTHY CROSS-COUNTRY AEROPLANE flight was made during the past week by Mr. Harry N. Atwood, a young aviator who has recently taken up the art of flying. Mr. Atwood, in a Wright-Burgess biplane, left Boston with a passenger on the morning of June 30 and flew to New London, Conn., a distance of 135 miles, reaching there some three hours later. Still carrying the passenger, he left New London Saturday morning, and three hours later reached Governor's Island, in New York Bay, after a flight which was marked by only one stop, just outside of New York City, where he was forced to come down for gasoline. The flight from this stop to Governor's Island was particularly sensational because Mr. Atwood made the first flight in a heavier-than-air machine over the City of New York. It has been expected that the various currents of air which arise from the skyscraper districts of lower Manhattan would make flying over the city very difficult, but Mr. Atwood found that, although these currents were very marked, they still were not so great as are sometimes found in mountain districts. After several short flights from Governor's Island, the aviator left there, on the morning of July 4, intending to fly down the Atlantic coast to a point opposite Washington and then cross-country to that city. However, he encountered a very high head wind all the way down the coast so that he found it impossible to go farther than Atlantic City on that day's flight. He reached Atlantic City after three stops for gasoline, and after making what he estimated as 250 air miles in five hours. This last trip from Governor's Island to Atlantic City was made alone.

ELEVEN AEROPLANES CROSSED THE ENGLISH Channel within a half hour of each other in the first half of the International Circuit Aviation Race which left Calais, France, on July 3. These machines were all that started in the race, and all made a successful passage.

THE INTERNATIONAL SPEED RACE for the Gordon Bennett Cup, which was won in 1909 by Mr. Glenn. H. Curtiss, an American, at Rheims, France, and in 1910 by Mr. Claude Graham-White, an Englishman, at Belmont Park, New York City, was won on July 1 at East Church, England, by Mr. Charles T. Weymann, an American, flying in a Nieuport monoplane. Mr. Weymann made the 93.2 miles in 71 min. and 36⅘ sec., an average of 78 mi. per hr. Indicating the increase in speed being made in flying, the 1909 race was for 12.4 miles, and it was made in 15 min. and 56 sec., a speed of 46.8 mi. per hr. The 1910 race was for 62.1 miles and was made in 61 min. and 4⅘ sec., a speed of 61 mi. per hr.

WIRELESS TELEGRAPH equipment of ocean-going vessels carrying more than 50 passengers will be compulsory after July 1 under an act of Congress passed June 24, 1910. A fine of $5,000 is to be imposed in cases where the vessels are not equipped with apparatus capable of transmitting messages at least 100 miles and in charge of an operator carrying a certificate issued by this or some foreign government. The Commissioner of Navigation has issued regulations governing wireless equipment under the same act, and three inspectors in charge of the Atlantic, Middle Atlantic and Pacific Divisions, respectively, and collectors of customs, are authorized to enforce the regulations.

Personals.

Mr Henry S. Graves, Chief Forester of the United States Bureau of Forestry, has been awarded the honorary degree of Master of Arts by Harvard University.

Maj. William V. Judson, M. Am. Soc. C. E., Corps of Engineers, U. S. A., has been awarded the honorary degree of Master of Arts by Harvard University.

Mr. Ralph Mojeski, M. Am. Soc. C. E., has been awarded the honorary degree of Doctor of Engineering by the University of Illinois.

Mr. Frank M. Williams, formerly State Engineer of New York, has taken a position as Chief Engineer of the Du Pont Road in Delaware.

Mr. John D. Maupin, formerly Master Mechanic of the Trinity & Brazos Valley Ry., has been promoted to the position of Superintendent of Motive Power of the same road.

Mr. P. J. Carter has been appointed Assistant Engineer of the Gulf, Colorado & Santa Fe Ry., with office at Galveston, Tex., succeeding Mr. K. B. Duncan, transferred to Topeka.

Mr. H. E. Breed, Assoc. M. Am. Soc. C. E., formerly Assistant Engineer with the New York State Highway Commission, has taken a position as Assistant Chief Engineer of the Du Pont Road, Delaware.

Maj. Edwin R. Stuart, Corps of Engineers, U. S. A., formerly in charge of military surveys in the Philippine Islands, has been appointed Professor of Drawing at the United States Military Academy at West Point.

Mr. Francis Head, M. Am. Soc. M. E., having recently completed the designs and estimate for the Philadelphia sewage pumping stations, will soon sail for Brazil to take a position as Engineer for the Sao Paulo Tramway, Light & Power Co.

Mr. George H. Benzenberg, Past-President of the American Society of Civil Engineers, was awarded the honorary degree of Doctor of Science at the commencement exercises of the University of Wisconsin, at Madison, on June 21.

Mr. Nathan G. Pearsall, formerly General Manager of the New Orleans Great Northern R. R. at Bogalusa, La., has been appointed Superintendent of the Louisiana Division of the Texas & Pacific Ry., with headquarters at New Orleans, La.

Mr. H. B. Voorhees, formerly Assistant to the President of the Baltimore & Ohio R. R., has been promoted to the position of General Superintendent of Transportation of the same road. Mr. James S. Murray has been appointed Assistant to the President, succeeding Mr. Voorhees.

Col. Henry G. Prout, M. Am. Soc. C. E., First Vice-President and General Manager of the Union Switch & Signal Co., New York City, has been awarded the honorary degree of Doctor of Laws by the University of Michigan. In 1902 Mr. Prout received the honorary degree of Master of Arts from Yale University.

Mr. Charles Gordon Curtis, President of the International Curtis Marine Turbine Co., was recently awarded the Rumford Medal of the American Academy of Arts and Sciences. It is interesting to note in this connection that the Rumford Medal of the Royal Society of Great Britain was awarded to Mr. C. A. Parsons, of the Parsons steam turbine fame, in 1902.

Mr. Theodore N. Ely, M. Am. Soc. M. E., Chief of Motive Power of the Pennsylvania R. R., has retired under the company's pension rules after 43 years of continuous service, for 17 years of which he has held his present position. He is a graduate of Rensselaer Polytechnic Institute, class of 1866, a member of the American Society of Civil Engineers, a member of the Institution of Civil Engineers (Great Britain) and a member of the American Institute of Mining Engineers and an honorary member of the American Institute of Architects.

Obituary.

Jackson Ellsworth Sickels, for many years a resident engineer on the Great Western Ry. of Canada, died in Washington, D. C., on June 25, from pneumonia. He was 80 years old.

Franklin A. Wilson, formerly President of the Maine Central R. R., died in Bangor, Me., on July 2, aged 78 years. He was a prominent lawyer and was a graduate of Bowdoin College.

W. L. Pierce, Superintendent of the Richmond Division of the Southern Ry., died at his home in Richmond, Va., on June 29. He was 49 years old and had been over 30 years with the Southern Ry.

Jay Osborne Moss, President of the Sandusky, Mansfield & Newark R. R., previous to its absorption by the Baltimore & Ohio R. R., died at his home in Sandusky, Ohio, on June 27, at the age of 74 years.

Howard Wood, President of the Wood Iron & Steel Co., Philadelphia, Pa., died at the Bryn Mawr Hospital in that city on July 1. He was 66 years old and a graduate of the University of Pennsylvania, class of 1864. Mr. Wood continued the business founded by his father, Alan Wood, one of Pennsylvania's pioneer iron masters.

Francis Schumann, M. Am. Soc. M. E., formerly President and General Manager of the Pennsylvania Iron Works, died at his home in Philadelphia, Pa., on June 29. Mr. Schumann was the builder of the tower of Philadelphia City Hall, and was prominent as a civil and mechanical engineer for many years. He was a past president of the Engineers' Club of Philadelphia, the first President of the American Foundrymen's Association and a member of the Franklin Institute.

Engineering Societies.

COMING MEETINGS.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 25-28. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 29-Sept. 1. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 12-15. Annual meeting at St. Paul, Minn. Secy., Clarence R. George, Houston, Texas.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 12-15. Annual convention at Atlantic City, N. J. Secy., A. P. Dane, Boston & Maine R. R., Reading, Mass.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 13-15. Annual convention at Glenwood Springs, Colo. Secy., F. D. Morris, P. O. Box 1052, Colorado Springs, Colo.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—The sixth annual convention was held at Newark, N. J., on Wednesday, Thursday and Friday, June 28-30. The four sessions of the convention were held at the City Hall. The attendance averaged about 40 members. In the absence of the President, Mr. Paul P. Bird, of Chicago, Mr. Daniel Maloney, of Newark, Vice-President of the Association, presided throughout the convention. At the opening session on Wednesday morning, Mayor Haussling, of Newark, made the address of welcome to the city, and Mr. Robt. H. Kuss, Assistant Smoke Inspector of Chicago, responded on behalf of the Association. The remainder of this session was taken up with routine business and verbal reports by some of the members of the work done and improvements effected during the past year. The social features included a trip to Coney Island by boat from Newark on Thursday afternoon.

The Wednesday afternoon session was opened with an illustrated lecture on "The Relation of the Gas Producer to the Smoke Problem," by Prof. R. H. Fernald, Consulting Engineer in the U. S. Bureau of Mines. The lecture was chiefly of an elementary nature, explaining in a general way the operation of some of the types of gas producers. The gas producer was advocated as a means of utilizing low quality fuels with a minimum of smoke nuisance. Prof. Fernald referred to a few plants which had been in continuous operation without shutdown for several years as being truly smokeless. He explained some of the early difficulties accompanying the introduction of the gas producer in this country by saying that the makers of producers had followed European practice in the matter of rating, whereas it was found that with American coals a considerably larger producer was required to supply an engine of given power. He stated that there were now 474 producer plants in the United States, of which 415 were operated on anthracite coal. These, however, were all small plants. Bituminous coal was used in all plants of large horse-power. In conclusion Prof. Fernald spoke emphatically in favor of central station plants and railway electrification as palliatives of the smoke evil.

The next paper was on the "Enforcement of the Smoke Prevention Ordinance in New York City," by Dr. Ernest J. Lederle, Commissioner of Public Health of New York. In the absence of the author, this was read by the Secretary, Mr. R. C. Harris, of Toronto, Can. This paper described the system of inspection, warnings and preferment of charges and gave statistics of the number of arrests and convictions and the amount of the taxes imposed during the past year.

A paper on "Smoke Prevention in Large Power Stations" was presented by Mr. James T. Whittlesey and Mr. Hervey S. Vasser, Chief Engineer and Assistant Chief Engineer, respectively, of the Public Service Corporation of New Jersey. Mr. Vasser read the first part of the paper, in which were outlined the difficulties of smoke prevention in the Public Service Corporation's power plants. The chief difficulty was the liability of sudden and unexpected variations in the load, which necessitated raising steam hurriedly. The normal periodic variations throughout the day could be foreseen and accommodated with little trouble from smoke. Frequently, however, according to Mr. Vasser, some accident would put an entirely unexpected demand upon the plant, which it was impossible to meet without producing considerable smoke. Mr. Vasser advocated improved methods of management in the boiler-room as the best plan for preventing smoke. He appeared to believe that CO_2 recorders and other instruments of the sort were of little value. Mr. Whittlesey discussed the experiments which had been tried at the Public Service Corporation power plant in the effort to comply with smoke ordinances. He mentioned as most effective the change which had been made at the Newark plant from bituminous coal to a high grade semi-bituminous coal, which was practically smokeless when properly used. Some experiments had been made with mechanical stokers, but the results appeared to be rather indefinite. Mr. Whittlesey exhibited a number of charts showing curves of smoke density measured according to the Ringelman chart. These curves showed that the density of smoke varied considerably throughout the day in an irregular manner. On some of the charts the effect of the coming on of the peak loads could be traced in the increase of smoke. In the discussion of this paper, Mr. Robert H. Kuss, of Chicago, described a smoke-recording device which automatically made a continuous record of the density of smoke produced by the stack to which it was connected. In this device samples of smoke from the stack were conducted through a tube of small bore and made to issue from a narrow slit so as to impinge upon a paper ribbon wound on a drum driven by clockwork.

A session held Wednesday evening was devoted to general discussion and brief addresses on mechanical stokers, steam jet devices and other means of smoke prevention.

At the Thursday morning session, Mr. Richard B. Watrous, of Washington, D. C., Secretary of the American Civic Association, gave an address on "Smoke Versus City Beauty." He stated that many administrative problems might be solved by making our cities more beautiful, for the reason that the character and morals of the inhabitants would be indirectly benefited by the influence of beautiful surroundings. It should not be attempted, he said, to oppose industrial activity in the effort to prevent smoke. He understood that the reduction of smoke was accompanied by greater fuel economy, so that smoke prevention would be in harmony with efforts to obtain greater power-plant efficiency. He stated that the damage done to property in the United States amounted to $500,000,000 per annum. This included damage to interior decorations and furnishings, as well as to the outside of buildings. He commended the efforts recently made at Pittsburg to reduce the smoke evil, and stated that Pittsburg could no longer truly be said to be the smokiest city.

Mr. Watrous was followed by Mr. C. D. Young, Assistant Engineer of Motive Power of the Pennsylvania Lines West of Pittsburg, who opened the discussion on the prevention of smoke on railways. Mr. Young began by explaining the difficulties of smoke prevention in railway work. He referred to the frequent necessity of quickly starting up a locomotive which might be standing in the roundhouse with its boiler cold, and to the sudden changes of load put on locomotives in service by change of grade, unexpected starts and stops and the resistance of reverse curves in freight yards, for example. It was not unfrequently necessary for the locomotive fireman to shovel from 5,000 to 6,000 lbs. of coal per hour, and this too from a moving platform, which increased the difficulty of the work. Mr. Young then told of the experience of the Pennsylvania R. R. in the use of mechanical stokers. After explaining some of the defects of various stokers tried, he described in detail the construction and operation of the Crawford stoker, a description of which was published in Engineering News, April 13, 1911, p. 450. He mentioned tests of this stoker, extending over a 40-hour period, during which 9,754 smoke observations were made, of which 9,050 gave a reading of zero on the Ringelman chart, while the highest reading taken was No. 4 on the chart. He stated that the Pennsylvania had now 23 locomotives equipped with this stoker, while 15 others were being equipped. Mr. Young expressed the opinion, however, that the results obtained with the stoker were not superior to what could be done by the best fireman. It was necessary that the adoption of mechanical stokers on locomotives be taken up gradually in order to give time for the men to be properly instructed in their use.

The discussion on railway smoke was continued at the Friday morning session, which was attended by representatives of the Pennsylvania and Erie Railroads and the Central R. R. of New Jersey. Mr. F. T. Howley, General Road Foreman of Engines of the Erie R. R., described the Erie's system of instructing firemen, and stated that no railroad was making greater efforts in the prevention of smoke. The question of smoke at roundhouses was brought up, and the opinion was expressed by the railway men that very little could be done in the way of preventing smoke at roundhouses. Mr. J. P. Brown, of Indianapolis, however, believed that the roundhouse smoke nuisance could be much abated if the railways were willing to build sufficiently high stacks at the roundhouses.

The election of officers resulted as follows: President, Daniel Maloney, Newark, N. J.; Vice-President, J. P. Brown, Indianapolis, Ind.; Secretary-Treasurer, R. C. Harris, Toronto, Canada. Indianapolis was selected as the convention city for 1912. The convention will be held in September instead of in June as heretofore.